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ABSTRACT: Public procurement can be highly vulnerable to corruption. This paper outlines a methodology and results in assessing corruption risks in public procurement and their impact on relative prices, using large databases on government contracts and tenders. Our primary contribution is to analyze how price differential in public procurement contracts can be explained by corruption risk factor (aggregated in a synthetic corruption risk index). While there are intrinsic limitations to our study (price differentials can come from structural reasons, such as a limited number of potential suppliers) it still provides a guiding tool to assess where corruption risks would have the biggest budgetary impact. Such analysis helps inform mitigating policies owing to the granular data used.

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WORKING PAPERS

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[5] The authors would like to thank colleagues form the European Union, the IMF, UKAID, the World Bank, for the very helpful comments.

Contents

I. Introduction: A Method to Assess Corruption Risks in Public Procurement

1. **Public procurement, a crucial way to implement government budgets, can be highly vulnerable to corruption** (IMF, 2019). Estimates of losses through procured spending amounts to about 10-20 percent, even in countries with relatively high integrity of their procurement systems in the European Union (Hafner et al., 2016). Consequences for public finances can be dire, as public procurement constitutes about 12 percent of global GDP or 11 trillion USD per year (Bosio et al., 2020). Corruption can lead to higher deficits and lower growth, due to (among others) inadequate quality and/or insufficient level of infrastructure (Schwartz et al., 2020).

2. **Does corruption explain higher prices paid for procured public goods or services?** This simple but crucial question has, in a nutshell, contrasted answers. There are, for example, policy experiments showing how strengthening–or simply introducing–rules that deter corruption tend to reduce the cost or improve the quality of procured goods and services (Banerjee et al., 2016). There are also microeconomic studies pointing at similar results (see, for example, Di Tella and Schargrodsky, 2003, on the procurement of medical goods in Argentina, or Palguta and Pertold, 2017, on public procurement in the Czech Republic, Coviello and Mariniello, 2014, on the role of transparency and publicity). Empirical studies can also suggest "red flags" of corrupt behaviors, which can subsequently inform the design of procurement rules (see Fazekas, Tóh, and King, 2016, on how to measure corruption risks in public procurement). For example, both Paguta and Pertold, (2017) and Coviello, Guglielmo, and Spagnolo (2018) show that when public officials can exert discretionary powers (usually for procurement contract values below a certain threshold) then there is a concentration of contracts awarded to specific bidders and/or untransparent bidders in terms of their owner structure. However, the fact that corrupt behaviors can lead to higher prices paid doesn't necessarily mean that either the impact is significant or that reducing the impact is worthwhile economically. In particular, corruption can, in some instances, lead to rather small costs, while other sources (inefficiencies in the procurement process, or costs associated to implement anti-corruption measures) can be a lot more significant (see Bandiera, Prat, and Valletti, 2009, for public procurement in Italy). A common denominator to all these studies is how uncompetitive public procurement processes can help corruption thrive, eventually translating into higher prices paid (Bandiera, Prat, and Valletti, 2009, Fazekas and Tóth, 2017) or lower quality of procured goods and services (Golden and Picci, 2005, Fazekas and Tóth, 2017).

3. **The main contribution of our paper is to assess whether or not red flags of corrupt behaviors have an impact on prices of procured goods and services**. We do so by estimating the impact of corruption risks (assessed through red flags), on relative prices (i.e., comparing prices paid with reference prices). Our approach has three main novelties and two caveats. First, we rely on very large databases, covering all regulated public procurement contracts available in the countries reviewed. We achieved that by gathering data from government web portals for public procurement. As a result, we can have broader results in terms of coverage than other papers of the literature that usually focus on sub-set of procurement contracts. Second, we focus on corruption risks in a more systematic way, by mapping seven red flags of corrupt behaviors, which correspond to risks identified in the literature (i.e., not only on procurement processes such as competitive procedure types, but also on the part of suppliers, for example by exploring the impact of concentration of procurement contracts on specific bidders). Thus, we assess through our estimations if these red flags have an explanatory power on relative prices. This is important in terms of informing anti-corruption policies, which is our third contribution. Indeed, a red flag can point to very granular policy recommendations, because our methodology enables policy makers to explore which sectors may be more vulnerable to corruption and/or what factors are the most important in explaining price differentials. We explore the policy analysis and recommendations in a companion paper (Basdevant and Fazekas, 2022). The first

caveat of our approach is that we focus on corruption risks and not actual instances of corruption. In particular, and like others working in this field, finding that our variables have an impact on relative prices gives an indication of potential corrupt behaviors, but other factors may be at play. For example, single bidding on specific markets may have nothing to do with corruption but more about structural features of these markets. Thus, our results need to be taken with caution by policy makers, which should subsequently further explore corruption vulnerabilities. The second caveat is that by nature of this quantitative exercise we do not explore how corruption risks could affect the quality of procured goods and services. This could nonetheless be the subject of further research but is left aside in the context of this paper.

4. **The rest of this paper focuses on the presentation of the results for the five pilot countries for which the methodology was developed: Georgia, Indonesia, Paraguay, Romania, and Uganda**. These countries were chosen as they had publicly available dataset on procurement contracts and provided a diverse representation of continents.[6] The dataset for the five pilot countries includes over 1.5 million contracts, capturing from 15 to 55 percent of total procured spending in each country. Our analysis provides a granular distinction between cases where, say, corruption risks could be high with, overall, limited impact on price differentials, versus cases where corruption risks would be small, but with potential large impacts on relative prices. We also develop a Corruption Risk Index (CRI), which can be of particular relevance to track more precisely corruption vulnerabilities (as opposed to one of its component, which, taken individually, may not provide enough information on corruption risks).

II. Assessing Vulnerabilities to Corruption Using Objective Data

5. **In this section, we present seven indicators of likely corrupt impediments to open competition in public tenders, which constitute our measurement of corruption risks in procurement using hard data.** We first present seven indicators, the “red flags”, that we use to compute a composite indicator, the CRI, based on a simple average of these seven red flags. Then we offer a balanced assessment of the strengths and weaknesses of our approach to measuring corruption risks. These “red flags” do not attempt to identify corruption per se, but instead to measure risks in an objective manner. The indicators used encompass the indicators typically used in the literature on the subject, but in a more comprehensive and consistent way. Indeed, most papers would typically focus on a subset of these seven indicators, as they usually only look at a very specific corrupt behavior (either for a specific behavior, or for a specific country, see Fazekas, Tóth, and King, 2016, or Fazekas and Kocsis, 2020 for a review as well as Table 1). In addition, the seven selected indicators can be consistently calculated across a large sample of publicly available procurement datasets, underpinning a globally standard methodology.

6. **Because our indicators are comprehensive and observable for all countries in our study, they allow the development of a synthetic CRI, which can also be used for cross-country comparisons**.[7] These seven red flags and the underlying corrupt behaviors are as follows (see also Appendix II):

- ***Single bidder contracts***, that is contract awarded in a tender where only one bidder participated, represents a straightforward way to gauge limited competition in public tenders. It can be a sign of corrupt practices in public procurement as corruption is more likely to arise and indeed easier to organize when there is only in participating company (Klasnja, 2016, Charron, et al., 2017; Fazekas, Tóth, et al., 2016).

[6] Since this study, the project was expanded to cover more countries https://public.tableau.com/app/profile/gti1940/viz/CorruptionCostTracker/Overviewofcountries?publish=yes

[7] Note that while cross-country comparisons are possible, they would not necessarily fully reflect idiosyncrasies in the development of each indicator (as, for example, procurement procedures differ across countries), and as such would be subject to caution.

- ***Non-open procedures***, leading to uncompetitive tenders (Auriol, Flochel, and Straub, 2016). Lack of open participation in procurement tenders can limit the number of competing bidders, thus opening an avenue for public official to extract an illegal rent from the procurement process. The most straightforward example of such risks is a high-value contract directly awarded to a bidder without any competition or request for quotations. As country regulatory contexts differ from each other and change over time, identifying non-open procedure types requires both observing tendering outcomes and conducting an in-depth analysis of procedural rules, either set in laws or secondary legislations.
- ***Lack of publication of call for tenders***, as limited publication can lead to uncompetitive tenders (Coviello and, Mariniello, 2014, Björkman, and Svensson, 2009, Lewis-Faupel et al., 2016, Zamboni Litschig, 2018). Not publishing call for tenders is also a notable deviation from the core principle of transparency of procurement processes established by the OECD (2016).
- ***Period for submitting bids***, can also represent vulnerabilities to corruption risks. This red flag is analyzed in two ways. Typically, a short period is associated with unfair competition (less time to prepare adequate bids). However, extensive submission periods can signal legal challenge and lengthy modifications of tendering terms which underpin favoritism towards a single bidder. This red flag is assessed, taking into account country-specific features (see Table 7 in Appendix II) of the degree to which different submission periods are associated with single bidding.
- ***Period for selecting the winning bid*** can also be a red flag for corruption risks (see also Fazekas and Kocsis, 2020).[8] A short period is associated to unfair competition (bids may not all be adequately assessed). In some cases, long decision periods can also signal that a particular bidder was favored because challenging the bid assessment, hence increasing the period for the final award decision, is a hallmark of irregularities.
- ***Spending concentration*** (by organization, by year) can also be a sign of corrupt practices as corruption could lead to a higher concentration of procured spending in specific bidders. Conversely, dominant market positions can be abused by bidders to extract corrupt rents.
- ***Share of suppliers registered in jurisdictions offering limited company and banking transparency***. This indicator is quite critical, as a company registered in such jurisdictions would typically avoid adequate oversight. As a result, it's easier, especially for trans-national companies, to engage in corrupt activities by facilitating secrecy on illegal payments made to public officials.

[8] There is, however, a trend in procurement systems to make an increasing use of negotiations which may result in longer periods for selecting the winning bid. For example, the EU introduced a "competitive dialogue" in its legal framework after the 2014 directives on procurement (see Saussier and Tirole, 2015).

Table 1. Red Flags Used in the Literature on Corruption in Procurement Systems

Source	Indicator(s) used	Country	Years	Sector	Potential for international comp	Included in the CRI (y/n)	Included in the CCT (y/n)
Auriol, Flochel, and Straub (2011)	Number of exceptional procedures	Paraguay	2004-2007	general procurement	HIGH Requires harmonization of definitions	y	y
Bandiera, Prat, and Valletti (2009)	Price differentials between goods either bought locally or procured.	Italy	2000-2005	standardized goods (e.g. paper)	LOW Price data is not readily available in most countries, many countries don't have national procurement agencies, national procurement agencies are likely to be captured in many countries.	n	y
Chong, Klien, and Saussier (2015)	Number of negotiated procedure	EU	2008-2012	general procurement	HIGH Requires harmonization of definitions	y	y
Coviello and Gagliarducci (2010)	Number of bidders Same firm awarded contracts recurrently Level of competition	Italy	2000-2005	general procurement	HIGH Number of bidders, recurrent contract award, and competitiveness of bids are available in many countries.	y	y
Di Tella and Schargrodsky (2003)	Price differential for standardized products	Argentina	1996-1997	health care	MEDIUM Detailed product-level price and quantity information is not readily available across many countries, but can be collected.	n	n
Fazekas and Kocsis (2015)	Composite risk indicator (e.g., singled bidder, period for submitting bids)	EU	2009-2014	general procurement	HIGH Requires harmonization of definitions	y	y
Ferwerda, Deleanu, and Unger (2016)	Composite indicator (e.g., short advertisement period)	EU	2006-2010	general procurement	HIGH Some of the indicators are based on data that is typically not collected centrally.	y	y
Golden and Picci (2005)	Ratio of physical stock of infrastructure to cumulative spending	Italy	1997	infrastructure	MEDIUM It is hard to compute comparable value of the stock of physical capital across countries different in the quality of infrastructure and geography.	n	n
Hyytinen, Lundberg, and Toivanen (2009)	Number and type of invited firms Use of restricted procedure	Sweden	1990-1998	cleaning services	HIGH Both number of bidders and procedure types are readily available in many countries.	y	y
Klasnja (2016)	Single bidder auctions Non-open procedure types	Romania	2008-2012	general procurement	HIGH Requires harmonization of definitions	y	y
Olken (2006)	Difference between in-kind benefits (rice) officially recorded and those reported in surveys	Indonesia	1998-1999	welfare spending	MEDIUM It is possible to design user surveys across a wide range of countries to track actual receipts, although it may be expensive.	n	n
Olken (2007)	Differences between prices and quantities officiallyy reported and independently audited	Indonesia	2003-2004	infrastructure (roads)	LOW Auditing large numbers of projects by independent engineers is costly and unlikely to allow for cross-country comparisons.	n	n

Sources: Authors from relevant publications.

7. **The CRI is based on a simple average of the seven individual red flags (after being normalized, see Appendix II)**. We score each contract, on each of the seven red flags, with a discreet score: 0 for lowest corruption risk, 0.5 for medium risk, and 1 for the highest risk. Then, we average the score across all contracts for each category (see Table 2 below). In the case of single bidding, for example, the score is either 0 or 1 at the contract level, and thus the score corresponds to the frequency of single bidding across all procurement contracts (e.g., in Romania 31 percent of contracts were awarded in tenders with a single

bidder). Then, we average the scores across the seven red flags for each contract to compute the CRI (Figure 1).[9] The CRI provides a more reliable indication of corruption risks because corruption would in general manifests itself through various techniques and strategies. Further, the CRI is primarily based on a cardinal measure of corruption (instead of ordinal), thus avoiding that a country is identified as a high corruption risk simply because its economy would perform less favorably than other countries. This is a particularly helpful contribution of this work, as not only do these indicators avoid the recourse to expert judgments, but also allow for country specificities to be factored in, while still providing an even-handed methodology and thus a common metric to assess corruption risks in any given country.

Table 2. Average Score for Each Red Flag

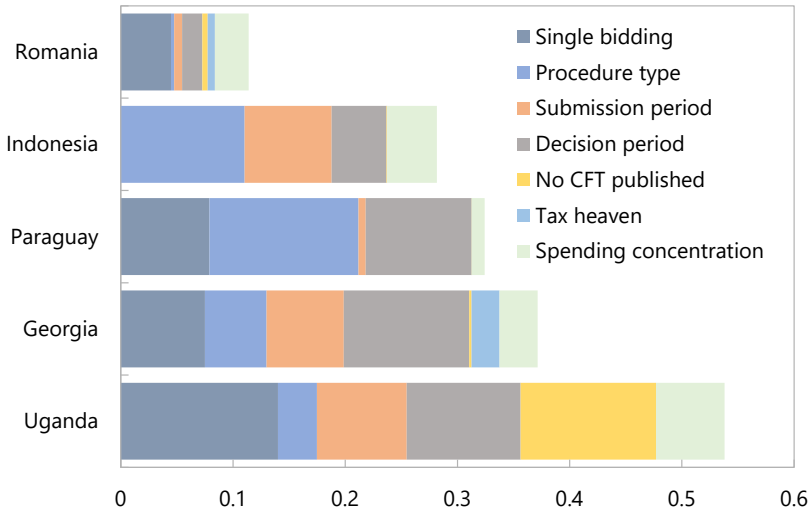
(Value between 0, lowest risk, and 1, highest risk)

	Single bidding	Procedure type	Submission period	Decision period	No CFT published	Tax heaven	Spending concentration	CRI (average)
Uganda	0.84	0.21	0.48	0.61	0.72	…	0.37	0.54
Georgia	0.52	0.38	0.48	0.78	0.01	0.17	0.24	0.37
Paraguay	0.47	0.80	0.04	0.57	0.00	…	0.07	0.32
Indonesia	0.00	0.66	0.47	0.29	0.00	…	0.27	0.28
Romania	0.31	0.02	0.05	0.13	0.03	0.04	0.21	0.11

Source: authors computations.

Figure 1. Corruption Risk Index and Its Components

(Indices of CRI components, 1=highest corruption risk)



Sources: Country authorities, and authors computations

8. **Strengths and limitations of the CRI**. As noted before, the seven red flags are also commonly used in the literature as indications of corruption risks (see IMF, 2018). When developing a composite indicator, we also have the following two advantages, which are, in spirit very similar to the approach proposed by the IMF (2018). First, The CRI is a more robust indicator of vulnerabilities to corruption than its individual components. Across, countries, sectors and over time, corruption typically thrives on various vulnerabilities, as corrupt officials would, especially when corruption is macro-critical, use several strategies to extract illegal rents. Thus, any consistent and reliable indicator of corruption risks, has to be able to gauge a range

[9] Red flags are defined using a cardinal order, low-medium-high risk. In effect they get assigned values, 0, 0.5, and 1, respectively, so that they can be turned into a composite score.

of such strategies. This feature is a potentially strong value added of the CRI, for both cross-country, cross-sectoral and time series comparisons, but also to assess how corruption may affect relative procurement prices (see next section). Second, The CRI is predominantly data-driven while being informed by established theories of corruption. The validity regressions outlined in Appendix II determine which definitions of risky categories are most closely aligned with the adopted definition of corruption. For example, the selection of high-risk procedure types, such as direct contracts, is driven by their association with single bidding rather than legislative intent or procedural design on paper. Against these two advantages, there are, however, two limitations. First, as discussed previously, in some countries/sectors, uncompetitive markets for specific goods can be related to structural features of the economy/market and not corrupt practices.[10] Further, the CRI (and more generally our approach) does not include capacity assessment. The primary reason for not including capacity evaluations is due to data limitations: capacity assessments are not necessarily available for all countries. Further, capacity assessments could potentially be questioned as being non-objective measures since they are derived from experts' judgements and are sometimes the result of self-evaluations (such as evaluations in the context of the Public Expenditure and Financial Accountability program, PEFA).

III. Estimating the Impact of Corruption Risks on Price Differentials

9. **We assess the budget implications of corruption risks, by estimating the impact of CRI (and other individual indicators) on prices in awarded contracts**. The regressions link the size of discounts offered by the winning firm compared to the auction reference price (which is based on standard market prices, and usually corresponds to the maximum budgetary allocation for a given purchase defined prior to the tender) based on corruption risks while controlling for year, contract value, main market, buyer location, and buyer type on the contract level (Fazekas and Tóth, 2018). Relative prices are calculated as actual contract values divided by the initially estimated contract value of the tender[11] (or through savings, if available directly in the dataset). One critical interest of such regressions is that they pave the way for bridging our large-scale micro-level dataset with macro aggregates such as budget deficit and to offer different macro spending estimates based on different risk levels in each country and sector. Naturally, and as noted previously, the fact that the CRI (or single indicators as shown in the rest of this section) is linked to higher relative prices is not sufficient to imply a causal relationship from corruption risks to prices. Indeed, higher prices can be explained by specific structural circumstances in some market or countries (please note that the regressions control for market specificities using a wide set of product market fixed effects).

[10] For example, individual instances of single bidding may be explained by a number of non-corrupt reasons (e.g., known most productive bidder, limited number of potential bidders for a specific market and/or country). While this feature could be seen as a limitation in the use of the CRI, it's also, in some ways, a strength. Indeed, as noted at the beginning of the paper, what we aim for is to provide an indicator of corruption risks and not corruption instances. As such, the use of the CRI (especially in informing relative price differential, as described in the next section), should be seen as a first step to gauge corruption risks in public procurement in a given country or sector. To further refine and assess the pertinence of the CRI, it should naturally be complemented by qualitative information, for example on specificities of certain markets. However, because qualitative information would be critically country-dependent, and hard to come-by, a broader framework to analyze corruption risks should be developed.

[11] Contract values are estimated by the procuring entity before the launch of the tender. It is needed in most countries for budgetary purposes (practically, the amount the public sector allocated for a contract depends on this estimate). Such estimations are highly regulated, requiring, *inter alia*, consulting past similar tenders and market analysis.

10. **We estimate five main regression models to estimate the relationship between the CRI and the relative prices of procured goods, works and services** (see Table 3 for the case of Georgia, Appendix III for the other countries, and descriptive statistics and histograms of relative prices are in Appendix I). Model 1 has CRI as the only independent variable with the other models (2-5) including a battery of control variables accounting for variation by product market (CPV division, location, and contract value), organizational framework (buyer type) and time-dependent shocks (year). Models 1-3 restrict relative prices to between 0.5 and 1.5 because those few extremely low relative prices (winning bid below 50 percent of the reference price) or extremely high relative prices (winning bid more than 50 percent above the reference) are most likely erroneous records that would bias our estimates. In addition, we also look at a more conservative set of regressions with relative prices restricted to 0.5-1, in essence cropping the upper end of the distribution (i.e., a few percent of the total sample depending on the country). The rationale behind removing relative prices above one is that in our country sample, just like in most other countries, awarding a contract above the reference price is unusual, requiring special circumstances and bureaucratic approvals hence represent a special case. Finally, model 5 also allows for a quadratic specification for CRI to capture non-linearities in the data. Crucially, for our subsequent discussion of corruption costs, the coefficients remain significant and largely the same size across the different specifications. Model 4 is chosen as the main prediction model for all countries as it is considered most robust with the widest range of control variables, and it has typically the highest explanatory power. While the non-linear models add to explanatory power, the improvement is little which we consider insufficient advantage in return for upping model complexity.

Table 3. Georgia – Main Results

	1	2	3	4	5
Dependent variable: relative price (RP) 1/	(0.5<RP<1.5)	(0.5<RP<1.5)	(0.5<RP<1.5)	(0.5<RP≤1)	(0.5<RP≤1)
CRI	0.276***	0.315***	0.312***	0.312***	0.222***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.012)
$(CRI)^2$					0.116***
					(0.016)
Year controls		✔	✔	✔	✔
Contract Value (100 quantiles)		✔	✔	✔	✔
CPV division		✔	✔	✔	✔
Buyer type			✔	✔	✔
Buyer location			✔	✔	✔
Observations	188,472	188,472	188,472	188,414	188,414
R-squared	0.15	0.20	0.21	0.21	0.21

Source: authors estimates.
Robust standard errors in parentheses. Clustered over buyers. *** p<0.01, ** p<0.05, * p<0.1
1/ Defined as the ratio of actual contract value and normal value (i.e. the value underpined by the reference price, based on standard market prices).

11. **To illustrate the outcome of our preferred specification (model 4), we show below the impacts of the CRI on relative prices across the five countries** (Table 10). All fiver response functions are upward sloping demonstrating the expected price increasing effect of corruption risks across the board. Interestingly, some of the curves are steeper (e.g., Romania) than others

(e.g., Uganda).[12] For example, in Romania, an additional red flag (1/7 points increase on the CRI score) is predicted to increase prices by 4.4 percentage points (0.307*(1/7)*100=4.4).

Table 4. Estimated Price impact of CRI Increase by Country

	Price elasticity to CRI 1/ (Unit)	Price impact of CRI increase 2/ (Percent)
Paraguay	0.39	5.5
Georgia	0.31	4.5
Romania	0.31	4.4
Uganda	0.10	1.4
Indonesia	0.07	1.0

Sources: Authors computations.

1/ Elasticities taken from model 4. Significance of the estimates shown in tables of "main results" regression in appendix II, except for Georgia where results are shown in Table 8.

2/ Everything equal, an additional red flag (1/7 points increase on the CRI score) increase prices by 1/7 times the elestacity.

12. **We also run alternative specifications, to explore how individual indicators affect relative prices**. These regressions can also be of particular use for investigating with more scrutiny what specific factor(s) in the CRI can contribute to overpricing. One could even go further by letting data dictate the relative weights of the CRI components. However, while doing so would bring a better fit, it would lose the ability of the CRI to be used as an easy-to-interpret and even-handed indicator of corruption risks. Further, corruption is likely to thrive (as noted by IMF, 2018 and 2019) when vulnerabilities are widespread across many potential channels.

Table 5. Georgia – Alternative Specifications

	1	2	3
Dependent variable: relative price (RP) 1/	(0.5<RP<=1)	(0.5<RP≤1)	(0.5<RP≤1) (> 4 contracts per year)
1.singleb	0.149***		
	(0.00111)		
1.nocft		-0.0192***	
		(0.00311)	
w_ycsh4			0.0567***
			(0.00364)
Observations	188,414	188,414	130,722
R-squared	0.40	0.06	0.07

Source: authors estimates.
Regression includes controls for contract values, buyer type, buyer location, market, and tender year.
Robust standard errors in parentheses. Clustered over buyers. *** p<0.01, ** p<0.05, * p<0.1
1/ Defined as the ratio of actual contract value and normal value.

13. **To illustrate the global applicability of our approach, we applied it to infrastructure overpricing in the European Union**. A prior study by Fazekas and Tóth (2017) looks at relative prices and a similar corruption risk index in infrastructure projects of 27 EU Member States (including the U.K.; but excluding Malta due to its small size). They find comparably diverse, albeit positive impacts of CRI on infrastructure

[12] Please note that in spite of our best efforts to standardize datasets and indicator definitions, non-negligible differences remain in terms of data quality, regulatory prescriptions, and data scope. By implication, the curves can be compared across countries only to a limited degree.

prices across countries with most low corruption countries such as the Netherlands showing a muted, in some cases even insignificant, cost impact of corruption risks. Reassuringly, our impact estimates appear largely consistent with such prior research with the impact estimated falling on the upper end of the EU distribution which is hardly surprising given the five countries in our pilot sample fall in the high corruption spectrum. When comparing Table 9 (right hand-side column) with Figure 2, please note that the latter depicts the full impact of CRI increasing from 0 to 1, while the former shows the marginal effect of an additional red flag, that is 1/7th CRI increase. Thus, the partial impacts depicted in Table 9 are much lower than the overall impact illustrated in Figure 2.

IV. Conclusion

14. **The methodology and its results presented in this study shows considerable potential to assist policy makers in identifying corruption risks in procurement systems and their costs**. In particular, the methodology leads to a very user-friendly output (see Basdevant and Fazekas, 2022), while the inputs are all shared in a transparent way and can be easily customized by users. Our methodology is also a helpful tool for policy makers and stakeholders to identify (i) sources of corruption risks (e.g., by sector, region, or public organization type) and (ii) reform measures to address these risks (by tackling the identified red flags).

15. **Our analysis provides useful guidance on potential anti-corruption measures in public procurement in the five countries covered**. First, as noted in Table 4, the impact of corruption risks is significant, with an additional red flag leading to a price increase of 1 to 5 percent. Beyond this broad result, a further granular observation of red flags can inform the direction of potential anti-corruption measures. Appendix II presents a more detailed analysis, and to illustrate our point, further scrutiny could be given to submission periods (among other red flags). For instance, countries can not only assess the rational for the length of their submission periods based on our red flag analysis, but also consider how they fare against other countries. This could lead to fruitful discussions on whether submission periods reflect some country-specific factors, or if they should consider revisiting submission periods to reduce corruption risks.

16. **Our analysis comes at an opportune time since the fight against the COVID-19 pandemic has put enhance scrutiny on public procurement contracts across the world**. Because of its granular approach, the methodology can be used to assess corruption risks (and their impact) in procured medical supplies. It can also be used to track in real time if these corruption risks are declining as a result of measures taken to strengthen the oversight of public spending. In particular, once established at a country level, the CCT can benefit from rapid updates as countries publish more procurement contracts.

17. **To support the broad goal of curbing corruption in public procurement, the development of web portals and databases for public procurement is essential**. The introduction of an e-procurement—an important step for increased transparency, lower transaction costs, and reduced discretion in decision-making—would be, in many countries, a critical step, but yet just a first step. Developing formal web portals for procurement should also go hand-in-hand with the development of databases for public procurement contracts, ideally as a machine-readable database. In particular, dedicated efforts could be considered to develop e-procurement systems in low-income countries (LIC).[13] Rolling out such systems for LIC could prove particularly helpful in curbing vulnerabilities to corruption in procurement systems, especially if using the tool presented in this paper, in addition to improving economic efficiency and market access more broadly (Fazekas and Blum, 2021).

[13] For an up-to-date overview of e-procurement adoptions around the world see the World Bank's tally: https://www.globalpublicprocurementdata.org/gppd/

18. **The authors are also working on adding further cost types such as cost overruns and also higher quality pricing information wherever available** (i.e., unit prices of standardized goods). This addition would enable a more granular assessment of how corruption may affect procurement costs. Additionally, the dynamic between the components of the CRI could be quite complex at a country level. As such, it may be helpful to further explore the interaction between them, for example through a machine learning approach.

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Appendix I. Data Collection Methodology and Descriptive Statistics

The data is entered by the procuring organizations into standard reporting forms through government-run electronic procurement platforms. For every observed tender, we have information from contract award announcements as publication is always mandatory, while information from calls for tenders may not be published under specific circumstances.

We developed an automated web crawler to scrape data from each of the official sources. The methodology is composed of the following steps. We use Python (together with other programs such as Java) to collect HTML, XML, and CSV outputs from the sources. As noted above, the collection of these data requires from countries having an open-data practice of disclosing procurement contracts on a web portal. All countries of this pilot are already advanced in their public disclosure of procurement data in rather standardized formats. We then transpose each publication from its original format into a uniformly structured data template, including converting structured text to standard data types (numbers, dates, enumeration values), and cleaning the database from nonsensical values and/or ballast information.

We then link all the information which describes a tender, where a tender ideally begins with one Call for Tenders (or more) followed by one Contract Award (or more) and completed by a series of payments (or contract completion announcement). We also take into account if any modifications or cancellations occur to the tender at any point during the process. After successfully linking related publications, we reconcile all linked data records to create a single best image of a public tender covering its whole tendering cycle (importantly, this is the step where we reconcile conflicting information or fill in empty fields if available in a related notice).

The data is then cross-checked manually with the publications' sources. Once checked manually, we standardize buyer s' and suppliers' names. For Indonesia and Uganda, we also implemented a multi-step token-based string-matching algorithm for observations with missing tender product codes. We used a combination of tender title, lot title, and/or product description to match them with relevant product codes. For full technical documentation and codes see: https://github.com/digiwhist/backend.

Table 6. Descriptive Statistics of Red Flags and the CRI

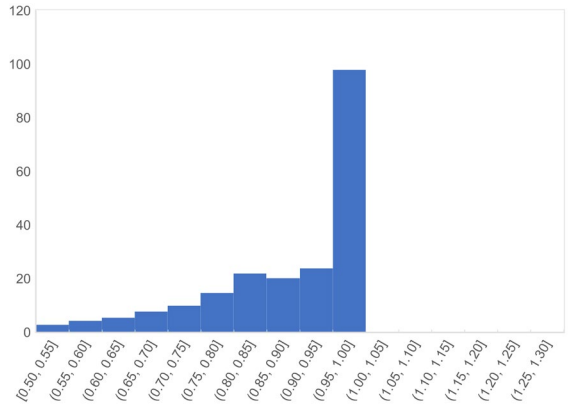
	Georgia	Romania	Indonesia	Paraguay	Uganda
Number of observations	202,299	620,261	682,070	142,878	47,641
Year	2011-2019	2007-2020	2012-2018	2010-2020	2016-2020
Nr. of buyer	2,833	9,710	4,146	434	190
Nr. of suppliers	18,203	47,533	93,292	13,277	10,810
Relative Price					
Mean	0.9	0.7	0.9	8.7	8,527.8
Standard Deviation	0.2	0.5	3.1	175.1	1,668,938.0
Missing Rate	3.69%	43.73%	1.17%	70.87%	3.21%
Corruption Risk Index (CRI)					
Mean	0.4	0.2	0.3	0.3	0.5
Standard Deviation	0.2	0.2	0.1	0.2	0.2
10^{th} percentile	0.2	0.0	0.1	0.1	0.2
90^{th} percentile	0.6	0.5	0.5	0.4	0.7
Single Bidding					
% single bidding = 0	49.0%	68.3%	99.9%	41.2%	31.4%
% single bidding = 1	51.0%	31.5%	0.1%	19.7%	68.6%
% single bidding = Missing	0.0%	0.2%	0.0%	39.2%	0.0%
Procedure Type (red flag = corr_proc)					
% corr_proc = 0	23.6%	83.7%	10.3%	19.2%	96.2%
% corr_proc = 1	75.4%	16.3%	47.6%	19.8%	1.8%
% corr_proc = 2	1.0%	…	41.9%	60.8%	2.0%
% corr_proc = Missing	0.0%	…	0.2%	0.3%	0.0%
Submission period (red flag =					
Mean	11.3	61.6	11.8	42.5	48.2
Standard Deviation	7.1	69.0	9.9	36.1	44.3
% corr_submp = 0	38.9%	26.4%	27.4%	81.2%	13.2%
% corr_submp = 1	23.9%	6.2%	51.2%	3.3%	9.9%
% corr_submp = 2	35.8%	…	20.7%	4.5%	10.1%
% corr_submp = Missing	1.4%	67.4%	0.7%	11.0%	66.9%
Decision Period (red flag = corr_decp)					
Mean	19.0	155.0	12.2	46.4	7.5
Standard Deviation	13.2	162.1	9.9	35.0	12.5
% corr_decp = 0	37.0%	25.8%	54.6%	21.4%	17.0%
% corr_decp = 1	62.8%	3.8%	30.9%	43.5%	29.6%
% corr_decp = 2	…	1.4%	14.1%	26.3%	-
% corr_decp = Missing	0.2%	69.0%	0.5%	8.9%	53.4%
No CFT					
% nocft = 0	98.6%	75.9%	99.5%	93.4%	45.4%
% nocft = 1	1.4%	24.1%	0.5%	6.6%	54.6%
Tax haven					
Foreign Supplier not in a tax haven	0.2%	0.6%	…	…	…
Foreign Supplier in a tax haven	0.0%	0.0%	…	…	…
Local Supplier	99.8%	99.4%	…	…	…
Contract Share (w_ycsh/proa_ycsh)					
Mean	0.4	0.3	0.7	0.0	0.6
Standard Deviation	0.4	0.4	0.4	0.1	0.4
10^{th} Percentile	0.0	0.0	0.1	0.0	0.0
90^{th} Percentile	1.0	1.0	1.0	0.1	1.0
Missing rate (%)	0.11%	0.62%	1.78%	6.92%	0.39%

Sources: Authors computations.

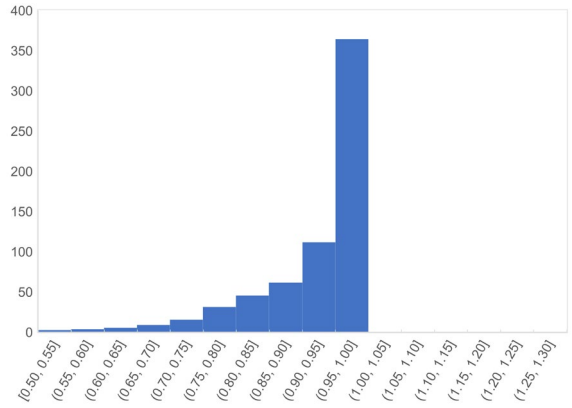
Figure 2. Observed Relative Price Distributions by Country

(Histogram, thousands of contracts, left axis, relative price on the x-basis)

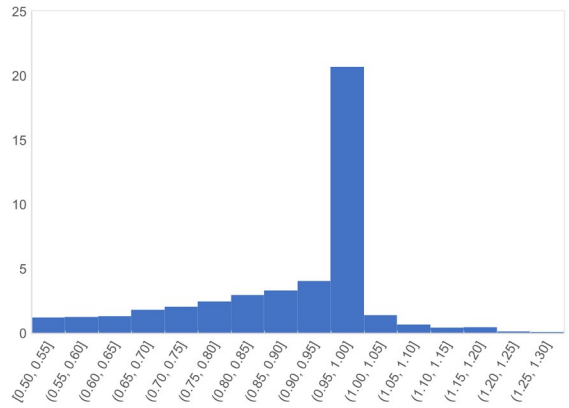
Georgia



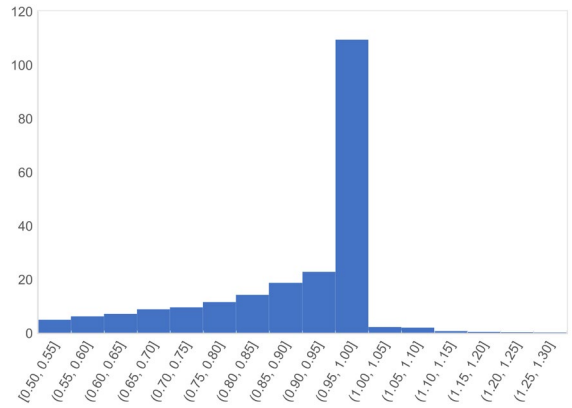
Indonesia



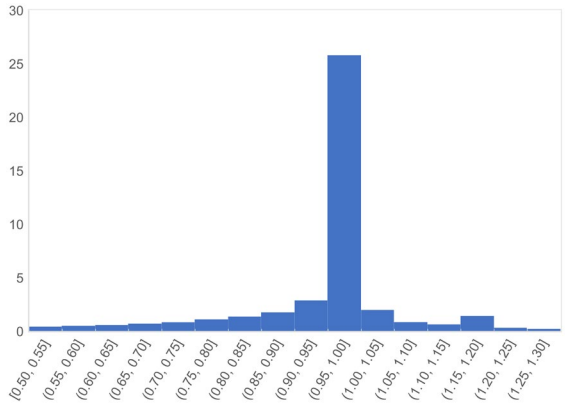
Paraguay



Romania



Uganda



Sources: countries authorities and authors computations.

Appendix II. Regressions Underpinning the Validity of the CRI

As our corruption definition implies lack of competition favoring a connected bidder, we consider two key outcomes of corrupt contracting being single bidding (lack of competition) and supplier contract share (repeatedly favoring the same company). Other indicators of corruption risks are related to these two outcomes in order to establish that they can serve as tools for corrupt contracting.

Assessing the relevance of red flags through indicators of uncompetitive bids. We first tested the validity of the red flags, by running a logit model where single bidding is the dependent variable and the red flags are explanatory variables plus including a host of economic controls, following the methodology of Fazekas and Kocsis, (2020).

$$Z_i = \alpha + \sum_{j=1}^{7} \beta_j X_{j,i} + \sum_{j=1}^{n} \beta_j C_{j,i} + \varepsilon_i \quad (1)$$

Where Z_i is the Log of the probability of the i[th] contract to be awarded by single bidding, X is the vector of red flags, and C control variables (contract values in real terms, types of market—based on assigned product codes, buyer types, and tender year). The results showed positive and significant coefficient for each of the seven indicators, thus suggesting that taken altogether they do explain how tendering process become less competitive, thus opening the door to corruption.

Assessing the relevance of red flags through indicators of supplier contract share. We also tested the validity of the indicators using suppliers share (S) in total procurement spending by procuring body. In a similar equation as the one above (although not in a logit model) we tested if the red flags were positive and significant in explaining a higher share of supplier contract. The regressions were limited to suppliers with more than 4 contracts per year. We have robustness test with larger (10+ contracts) as well as smaller (3+ contracts) entities, results don't change much. The reason excluding very small entities is that they trivially have high concentration, e.g., if you have a 1 contract entity it will trivially have 100 percent concentration.

$$S_i = \alpha + \sum_{j=1}^{7} \beta_j X_{j,i} + \sum_{j=1}^{n} \beta_j C_{j,i} + \varepsilon_i \quad (2)$$

We test the validity of the five remaining red flags (on top of single bidding and winner contract share) in these two sets of validity regressions. The precise definition of each red flag and the evidence for their validity is discussed one by one below.

For the two indicators related to time periods (submission of bids and decision), we split the data into deciles and mark as risky the deciles that significantly increase the probability of single bidding. One difficult aspect with these two indicators is that because of country-specific market and institutional conditions, the notion of an inadequate period for either submitting bids or deciding on the winning bidder varies. Yet, we want to avoid that our indicators are based on expert judgments, and instead we rely on hard data.

- To "let the data speak," we ran two types of regressions (see above), where the dependent variable is either single-bidding contracts (in a logit model), or the share of procurement contract value awarded to a given bidder (in fixed-effects OLS regressions). Both models are run with two alternative explanatory variables (as well as a host of controls): the advertisement period (in the case of tends submissions), and the period for making the decision.
- In both cases, we refer to the period as the deviation from a norm. To identify the norm, we split periods (for both submission and decision) into deciles. We then identify in each case a decile that will serve as a norm, i.e., associated with more likely open and competitive bidding process, either because it has the

longest time period of all deciles (in the case of submission) or because it has the value closest to the average decision period.

- Using the two regression models mentioned above, we search for significant and positive coefficients of the difference between the norm and the time period of each decile, as such a coefficient would indicate a higher probability of single bidding (in the first model) and/or higher spending concentration (in the second model).
- When using these two regression models, we are not looking for the "best fit" or causal identification but instead an indication that these indicators are correlated across a range of market contexts, as corruption is expected to manifest itself through a wide range of indicators and/or change over time, as discussed earlier in the paper.

Results confirm that in most cases short durations are associated with a significant impact on single bidding contracts and higher share of procurement spending on specific bidders (Table 9 for single bidding, and Table 10 for spending concentrated on specific bidders). The results clarify what categories of time periods can be considered as corruption risks (Table 7 and Table 8).

Table 7. Submission Period Threshold Red Flags by Country

Country	Red flags		Not a red flag
	High risk	Medium risk	
Georgia	Less than 6 days	Less than 13 days	More than 13 days
Indonesia	0 to 7 days	8 to 14 days	More than 14 days
Paraguay	Less than 13 days or 31 to 47 days	13 to 30 days	16 to 20 days or more than 47 days
Romania	30 to 33 days if procedure type is open or negotiated with publication and 9 to 14, and 65 to 378 days for the rest	…[1]	Less than 30 days and more than 33 days for open and negotiated with publication procedure types and less than 9 and more than 14 for the rest.
Uganda	Less than 17 days	17 to 41 days	More than 41 days

Sources: Authors' computations.

[1] Not including medium risk for Romania was a choice coming from the validity regressions shown in Table 9 and 10. In essence, there was no improvement to be made from adding an intermediate risk category (the regression models did not improve).

Table 8. Decision Period Threshold Red Flag by Country

Country	Red flags		Not a red flag
	High risk	Medium risk	
Georgia	Less than 14 days or more than 25 days		14 to 25 days
Indonesia	Less than 4 days	5 to 11 days or more than 25 days	11 to 25 days
Paraguay	0 to 22 days	23 to 64 days	More than 64 days[1]
Romania	Less than 32 days	33 to 53 days	More than 50 days
Uganda	1 day or more than 14 days		2 to 14 days

Source: Authors' computations.

[1] While 64 days could be seen, in absolute terms, as an excessive period for decision making in simple procurement processes. However, these periods are derived from regressions in Table 9 and 10. In both tables, medium risks (23-64 days) are associated with higher single bidding rate and higher spending concentration, so they could indicate risky behavior. Nevertheless, it could still be beneficial to shorten decision periods in general in Paraguay to lessen the administrative burden and make purchasing timelier.

Table 9. Validation Using Single Bidding

	Georgia	Indonesia	Paraguay	Romania	Uganda
Dependent variable: Single bidding	(Coefficients, std. dev. in parathesis below)				
Non-open procedures					
Medium risk red flag /1	0.128***	0.418**	0.952***	1.081***	0.316***
	(0.016)	(0.191)	(0.037)	(0.018)	(0.114)
High risk red flag /1	0.542***	0.582**	1.373***	…	1.662***
	(0.052)	(0.290)	(0.040)	…	(0.100)
Submission period					
Medium risk red flag /2	0.109***	0.865***	0.138**	0.205***	1.465***
	(0.015)	(0.168)	(0.060)	(0.017)	(0.054)
High risk red flag /2	0.145***	1.490***	0.406***	…	1.785***
	(0.012)	(0.170)	(0.050)	…	(0.054)
Decision period					
Medium risk red flag /3	0.0709***	0.855***	0.469***	0.344***	0.275***
	(0.010)	(0.124)	(0.023)	(0.018)	(0.042)
High risk red flag /3	…	1.537***	0.875***	0.8402***	…
	…	(0.126)	(0.026)	(0.027)	…
Call for tender not published	…	12.61	1.453***	0.3943***	4.226***
	…	(1027)	(0.092)	(0.018)	(0.102)
Tax haven					
Foreign supplier in tax haven	-0.0408	…	…	-0.6345***	…
	(0.255)	…	…	(0.157)	…
Domestic supplier	-0.831***	…	…	-0.7660***	…
	(0.110)	…	…	(0.039)	…
Observations	200403	647401	80643	544419	46669
Pseudo-R^2	0.05	0.10	0.13	0.12	0.47

Source: Authors estimates.
Regression includes controls for contract values, buyer type, market, and tender year.
*** p<0.01, ** p<0.05, * p<0.1
1/ See Table 7 for definition for each country.
2/ See Table 3 for definition for each country.
3/ See Table 4 for definition for each country.

Table 10. Validation of Red Flags Using Supplier Contract Share

	Georgia	Indonesia	Paraguay	Romania	Uganda
Dependent variable: Supplier contract share 1/	(Coefficients, std. dev. in parathesis below)				
Single bidding	0.0693***	0.122***	0.00609***	0.0141***	-0.0524***
	(0.001)	(0.022)	(0.001)	(0.001)	(0.007)
Non-open procedures					
Medium risk red flag /2	0.00781***	0.0678***	0.00795***	-0.004*	0.0620***
	(0.002)	(0.004)	(0.001)	(0.002)	(0.022)
High risk red flag /2	0.237***	0.173***	0.00796***	…	0.183***
	(0.009)	(0.005)	(0.001)	…	(0.034)
Submission period					
Medium risk red flag /3	-0.0558***	0.0141***	0.00690***	-0.0174***	0.0476***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.011)
High risk red flag /3	-0.0621***	0.0128***	-0.00574***	…	0.115***
	(0.002)	(0.002)	(0.002)	…	(0.011)
Decision period					
Medium risk red flag /4	0.00791***	-0.0206***	0.00866***	-0.0141***	-0.0656***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.008)
High risk red flag /4	…	-0.0117***	0.0216***	0.0259***	…
	…	(0.002)	(0.001)	(0.003)	…
Call for tender not published	…	0.109***	0.00658	0.0045*	0.184***
	…	(0.019)	(0.014)	(0.002)	(0.017)
Tax haven					
Foreign supplier in tax haven	-0.688***	…	…	-0.0606***	…
	(0.087)	…	…	(0.023)	…
Domestic supplier	-0.716***	…	…	-0.0995***	…
	(0.039)	…	…	(0.007)	…
Observations	139891	251986	75762	394770	28994
R^2	0.23	0.19	0.25	0.32	0.08

Source: Authors estimates.
Regression includes controls for contract values, buyer type, market, and tender year.
*** p<0.01, ** p<0.05, * p<0.1
1/ More than 4 contracts per year.
2/ See Table 7 for definition for each country.
3/ See Table 3 for definition for each country.
4/ See Table 4 for definition for each country.

Administrative procedures can also be a red flag for corruption risks when they lead to the lack of competition. Similarly, to the issue we faced with time periods, assessing the non-openness of procedures without using experts' judgments (and thus some degree of perception) is difficult. To do so we followed a methodology similar to the one described above for the duration indicators. We first identify all administrative procedure types related to public procurement (e.g., if there is a minimum number of bidders required), through text search in laws, secondary legislations, and tender documents. Following the logic of identifying risky categories introduced above for period length indicators, we run the same set of regressions with single bidding and concentration of procurement spending by specific bidders as dependent variables. We employ the same set of control variables. We denote those procedure types as risky, hence marked as red flags, which have a significant and positive link between the procedure type and the probability of single-bidding and/or concentration risk. For further granularity, we decompose the red flags into high and medium corruption risks, depending on the size of the coefficients with direct awards without any expectation of competition representing the highest risk and invitation tenders where at least the invited bidders are expected to compete as medium

risk. Moreover, those procedure types which are statistically indistinguishable from the reference category of open procedure type are classified as non-risky (Table 11, “not a red flag” column). Full regression results are reported in Table 9 and Table 10.

Table 11. Non-Open Procedure Red Flags

Countries	High risk red flag	Medium risk red flag	Not a red flag
Georgia	1. e-Procurement Procedure (GEO) 2. e-Procurement Procedure (GEO) via price list	1. Electronic Tender (SPA) 2. Electronic Tender (SPA) via price list 3. Simplified Electronic Tender (SPA) 4. Simplified Electronic Tender (SPA) via price list.	1. Donor electronic procurement procedure (DEP) 2. Electronic Tender (DAP) 3. Electronic Tender Without Reverse Auction (NAT) 4. Electronic Tender Without Reverse Auction (NAT) via price list 5. Simplified Electronic Tender Without Reverse Auction (NAT) 6. Simplified Electronic Tender Without Reverse Auction (NAT) via price list 7. Simplified Electronic Tender (DAP) 8. Simplified Two Stage Electronic Tender (MEP) 9. Two Stage Electronic Tender (MEP) 10. Two Stage Electronic Tender (MEP) via price list
Uganda	1. Restricted	1. Approaching Bidders	1.Open 2.Negotiated 3.Negotiated without publication 4.Negotiated with publication
Romania	1. Negotiated 2. Negotiated without publication		1.Open 2. Approaching bidders 3. Competitive dialog 4. Negotiated with publication 5. Restricted
Paraguay	1. Direct contracting 2. Other	1. Open within threshold	1. Open auction 2. Limited tendering
Indonesia	1. e-Lelang Pemilihan Langsung 2. e-Penunjukan Langsung 3. e-Seleksi Langsung 4. Lelang Pemilihan Langsung –Pascakualifikasi Satu File - Harga Terendah Sistem Gugur	1. e-Lelang Sederhana,e-Lelang Umum 2. e-Seleksi Umum 3. Lelang Sederhana - Pascakualifikasi Satu File - Harga Terendah Sistem Gugur 4. Lelang Sederhana - Prakualifikasi Dua File - Kualitas dan Biaya 5. Lelang Sederhana - Prakualifikasi Dua File - Sistem Nilai 6. Lelang Sederhana - Prakualifikasi Satu File - Biaya Terendah 7. Lelang Umum - Pascakualifikasi Dua File - Sistem Nilai 8. Lelang Umum - Pascakualifikasi Dua File - Sistem Umur Ekonomis, Lelang Umum - Pascakualifikasi Satu File - Harga Terendah Sistem Gugur 9. Lelang Umum - Prakualifikasi Dua File – Kualitas, Lelang Umum - Prakualifikasi Dua File - Kualitas dan Biaya 10. Lelang Umum - Prakualifikasi Dua File - Sistem Nilai 11. Lelang Umum - Prakualifikasi Dua Tahap - Harga Terendah Sistem Gugur 12. Lelang Umum - Prakualifikasi Dua Tahap - Sistem Nilai 13. Lelang Umum - Prakualifikasi Satu File - Biaya Terendah 14. Lelang Umum - Prakualifikasi Satu File - Harga Terendah Sistem Gugur 15. Lelang Umum - Prakualifikasi Satu File - Pagu Anggaran 16. Seleksi Umum - Pascakualifikasi Satu File - Harga Terendah Sistem Gugur 17. Seleksi Umum - Pascakualifikasi Satu File – Kualitas 18. Seleksi Umum - Prakualifikasi Dua File – Kualitas 19. Seleksi Umum - Prakualifikasi Dua File - Kualitas dan Biaya 20. Seleksi Umum - Prakualifikasi Dua File - Pagu Anggaran 21. Seleksi Umum - Prakualifikasi Dua File - Sistem Nilai 22. Seleksi Umum - Prakualifikasi Satu File - Biaya Terendah 23. Seleksi Umum - Prakualifikasi Satu File - Pagu Anggaran	1. e-Lelang Terbatas 2. e-Seleksi Sederhana 3. Lelang Terbatas - Pascakualifikasi Satu File - Harga Terendah Sistem Gugur 4. Lelang Terbatas - Prakualifikasi Dua File - Sistem Nilai 5. Lelang Terbatas - Prakualifikasi Dua Tahap - Harga Terendah Sistem Gugur 6. Lelang Terbatas - Prakualifikasi Satu File - Harga Terendah Sistem Gugur 7. Seleksi Sederhana - Pascakualifikasi Satu File - Biaya Terendah 8. Seleksi Sederhana - Pascakualifikasi Satu File - Harga Terendah Sistem Gugur 9. Seleksi Sederhana - Pascakualifikasi Satu File – Kualitas 10. Seleksi Sederhana - Pascakualifikasi Satu File - Pagu Anggaran, Seleksi Sederhana - Prakualifikasi Dua File – Kualitas 11. Seleksi Sederhana - Prakualifikasi Satu File - Biaya Terendah 12. Seleksi Sederhana - Prakualifikasi Satu File - Pagu Anggaran

Source: Authors Assessment.

The last two indicators, the lack of published tenders and the residency in tax heavens of suppliers[14] are also tested using our two regression models, and also contribute to informing transnational aspects of corruption. Using the two models we found again positive[15] and significant coefficients, thus reinforcing the choice of all these seven red flags. For the suppliers registered in jurisdictions to avoid disclosing details on their ownership, we relied on an independent, objective metrics of company and financial secrecy in countries and territories developed by the Tax Justice Network.[16] This type of indicator is not only helpful for the direct purpose of identifying corruption risks in the procurement system or a given country, it can also inform how transnational corruption can occur.

Arguably, both single bidding and concentration of procurement spending on specific bidders are proxy indicators of corruption. This means that they can arise due to non-corrupt conditions as well as corruption may happen without their presence. Our methodology tries to minimize these measurement errors. First, we looked for association and co-occurrence between single bidding and high spending concentration outcomes on the one hand and known methods and signals for favoring connected bidders such as direct awards or short advertisement periods on the other hand. Such co-occurrence of risky tendering processes and outcomes should lower our measurement error. Second, while we indeed expect a positive correlation between our corruption risk indicators, we also expect the fit to be far from perfect which suggests that risky tendering process can give rise to corruption even in the absence of our simple indicators of restricted competition (for example when bidders collude with each other while bribing public officials at the same time).[17]

While empirical estimations broadly support the selection of red flags, counter-intuitive results serve as guidance to further improve data quality and reinforce the need to rely on a broad composite indicator and not just a limited set of indicators. For example, in the Table 10 below, which presents the results of the validation through supplier contract share, some results are not congruent with that of the validation using single bidding (Table 9). Even when a risk indicator has a significant positive impact on one of the outcomes, say single bidding, it can have insignificant or negative impact on the other one, say supplier contract share. In the case of Romania, for example, some of the risk indicators which behave as expected for the single bidder regression, they are negative significant in the supplier contract share regression. This could be caused, inter alia, by reliability issues in the identification of businesses, making the corresponding regression noisier. Overall, the single bidding regression are more reliable hence offer sufficient evidence for indicator validity (Fazekas and Kocsis, 2020). Even the counter-intuitive results can suggest relying on a broad composite indicator, as corruption risks may not always be adequately capture by one specific indicator.

[14] While the information on tax heaven residency of suppliers is helpful, as information on beneficial owners become more widely available it would be helpful in subsequent iterations to include information on beneficial owners residency.

[15] For the case of suppliers registered in jurisdictions no favoring transparency on ownership, the reference category can either be foreign suppliers not registered in such jurisdictions or domestic firms. Similarly, foreign suppliers registered in those have a negative coefficient compared to other foreign suppliers (stronger test), however their coefficient is always larger than national suppliers (weaker test). While this evidence is not as strong as we would like it, it is nevertheless confirmatory and given the large literature on the subject we included it in the CRI.

[16] https://fsi.taxjustice.net/en/introduction/fsi-results

[17] Please also note that the two regressions for each country may not yield fully congruent results, that is while a risk indicator has a significant positive impact on one of the outcomes, say single bidding, it can have insignificant or negative impact on the other one, say supplier contract share. For example, for Romania some of the risk indicators which behave as expected for the single bidder regression, they are negative significant in the supplier contract share regression. This is likely due to the lack of reliable organization IDs in Romania making the latter regression noisier. In such situations, the single bidding regression are more reliable hence offer sufficient evidence for indicator validity.

Appendix III. Additional Price Regressions

Paraguay

Table 12. Paraguay – Main Results

	1	2	3	4	5
Dependent variable: relative price (RP) 1/	(0.5<RP<1.5)	(0.5<RP<1.5)	(0.5<RP<1.5)	(0.5<RP≤1)	(0.5<RP≤1)
CRI	0.378***	0.380***	0.371***	0.386***	0.554***
	(0.0245)	(0.0201)	(0.0191)	(0.0162)	(0.0563)
$(CRI)^2$					-0.306***
					(0.0958)
Year controls		✔	✔	✔	✔
Contract Value (100 quantiles)		✔	✔	✔	✔
CPV division		✔	✔	✔	✔
Buyer type			✔	✔	✔
Buyer location			✔	✔	✔
Observations	25,597	25,597	25,597	23,551	23,551
R-squared	0.09	0.164	0.168	0.242	0.243

Source: authors estimates.
Robust standard errors in parentheses. Clustered over buyers. *** p<0.01, ** p<0.05, * p<0.1
1/ Defined as the ratio of actual contract value and normal value.

Table 13. Paraguay – Alternative Specification

	1	2	3
Dependent variable: relative price (RP) 1/	(0.5<RP<=1)	(0.5<RP≤1)	(0.5<RP≤1) (> 4 contracts per year)
1.singleb	0.0851***		
	(0.00375)		
1.nocft		0.0229**	
		(0.00935)	
w_ycsh4			0.0573***
			(0.0145)
Observations	23,398	23,551	22,859
R-squared	0.24	0.17	0.17

Source: authors estimates.
Regression includes controls for contract values, buyer type, buyer location, market, and tender year.
Robust standard errors in parentheses. Clustered over buyers. *** p<0.01, ** p<0.05, * p<0.1
1/ Defined as the ratio of actual contract value and normal value.

Uganda

Table 14. Uganda – Main Results

	1	2	3	4	5
Dependent variable: relative price (RP) 1/	(0.5<RP<1.5)	(0.5<RP<1.5)	(0.5<RP<1.5)	(0.5<RP≤1)	(0.5<RP≤1)
CRI	0.0845***	0.0863***	0.0913***	0.0996***	0.0703
	(0.024)	(0.0224)	(0.0218)	(0.0191)	(0.0475)
$(CRI)^2$					0.0347
					(0.0527)
Year controls		✔	✔	✔	✔
Contract Value (100 quantiles)		✔	✔	✔	✔
CPV division		✔	✔	✔	✔
Buyer type			✔	✔	✔
Buyer location			✔	✔	✔
Observations	41,394	41,394	41,394	35,793	35,793
R-squared	0.02	0.041	0.066	0.103	0.104

Source: authors estimates.
Robust standard errors in parentheses. Clustered over buyers. *** p<0.01, ** p<0.05, * p<0.1
1/ Defined as the ratio of actual contract value and normal value.

Table 15. Uganda – Alternative Specification

	1	2	3
Dependent variable: relative price (RP) 1/	(0.5<RP<=1)	(0.5<RP≤1)	(0.5<RP≤1) (> 4 contracts per year)
1.singleb	0.0330***		
	(0.0109)		
1.nocft		0.0524***	
		(0.00957)	
w_ycsh4			0.0148**
			(0.00618)
Observations	35,793	35,793	22,334
R-squared	0.09	0.11	0.09

Source: authors estimates.
Regression includes controls for contract values, buyer type, buyer location, market, and tender year.
Robust standard errors in parentheses. Clustered over buyers. *** p<0.01, ** p<0.05, * p<0.1
1/ Defined as the ratio of actual contract value and normal value.

Romania

Table 16. Romania – Main Results

	1	2	3	4	5
Dependent variable: relative price (RP) 1/	(0.5<RP<1.5)	(0.5<RP<1.5)	(0.5<RP<1.5)	(0.5<RP≤1)	(0.5<RP≤1)
CRI	0.325***	0.312***	0.311***	0.307***	0.491***
	(0.0423)	(0.0348)	(0.0327)	(0.0331)	(0.0155)
$(CRI)^2$					-0.437***
					(0.0323)
Year controls		✔	✔	✔	✔
Contract Value (100 quantiles)		✔	✔	✔	✔
Contract type		✔	✔	✔	✔
CPV division		✔	✔	✔	✔
Buyer type			✔	✔	✔
Buyer location			✔	✔	✔
Observations	247,750	247,750	247,750	233,946	233,946
R-squared	0.0898	0.131	0.139	0.159	0.167

Source: authors estimates.
Robust standard errors in parentheses. Clustered over buyers. *** p<0.01, ** p<0.05, * p<0.1
1/ Defined as the ratio of actual contract value and normal value.

Table 17. Romania – Alternative Specification

	1	2	3
Dependent variable: relative price (RP) 1/	(0.5<RP<=1)	(0.5<RP≤1)	(0.5<RP≤1) (> 4 contracts per year)
1.singleb	0.111***		
	(0.0038)		
99.singleb	0.0557***		
	(0.00772)		
1.nocft		0.0218***	
		(0.00375)	
w_ycsh4			-0.00293
			(0.00603)
Observations	233,946	233,946	159,139
R-squared	0.20	0.09	0.09

Source: authors estimates.
Regression includes controls for contract values, buyer type, buyer location, market, and tender year.
Robust standard errors in parentheses. Clustered over buyers. *** p<0.01, ** p<0.05, * p<0.1
1/ Defined as the ratio of actual contract value and normal value.

Indonesia

Table 18. Indonesia – Main Results

	1	2	3	4	5
Dependent variable: relative price (RP) 1/	(0.5<RP<1.5)	(0.5<RP<1.5)	(0.5<RP<1.5)	(0.5<RP≤1)	(0.5<RP≤1)
CRI	0.0800***	0.101***	0.0699***	0.0700***	-0.0632***
	(0.00546)	(0.00721)	(0.00546)	(0.00546)	(0.0139)
$(CRI)^2$					0.2079***
					(0.01867)
Year controls		✔	✔	✔	✔
Contract Value (100 quantiles)		✔	✔	✔	✔
Contract type		✔	✔	✔	✔
CPV division		✔	✔	✔	✔
Buyer type			✔	✔	✔
Buyer location			✔	✔	✔
Observations	655,861	654,590	654,590	654,262	654,262
R-squared	0.014	0.058	0.142	0.142	0.145

Source: authors estimates.
Robust standard errors in parentheses. Clustered over buyers. *** p<0.01, ** p<0.05, * p<0.1
1/ Defined as the ratio of actual contract value and normal value.

Table 19. Indonesia – Alternative Specification

	1	2	3	4
Dependent variable: relative price (RP) 1/	(0.5<RP<=1)	(0.5<RP≤1)	(0.5<RP≤1)	(0.5<RP≤1) (> 4 contracts per year)
1.singleb	0.0256***			
	(0.00555)			
1.corrbid		0.0388***		
		(0.00134)		
2.corrbid		0.0546***		
		(0.00191)		
1.nocft			0.0149**	
			(0.00681)	
w_ycsh4				0.0222***
				(0.00246)
Observations	654,262	654,262	654,262	244,579
R-squared	0.14	0.19	0.14	0.14

Source: authors estimates.

Regression includes controls for contract values, contract type, buyer type, buyer location, market, and tender year. Model 2 shows an alternative specification to the bidding structure in Indonesia, instead of single bidding we define cut-offs based on the distribution of the bidding behaviour such as 1.corr_bid corresponds to 12 to 22 bidders and 2.corr_bid corresponds to 1 to 11 bidders.

Robust standard errors in parentheses. Clustered over buyers. *** p<0.01, ** p<0.05, * p<0.1
1/ Defined as the ratio of actual contract value and normal value.

PUBLICATIONS

Assessing Vulnerabilities to Corruption in Public Procurement and Their Price Impact

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