Beyond leakages

Quantifying the Effects of Corruption on the Water and Sanitation Sector in Latin America and the Caribbean

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Water and Sanitation Division

Innovation in Citizen Services Division

TECHNICAL NOTE Nº IDB-TN-02055

October 2020

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Inter-American Development Bank

Cataloging-in-Publication data provided by the
Inter-American Development Bank
Felipe Herrera Library
Beyond leakages: quantifying the effects of corruption on the Water and Sanitation sector in Latin America and the Caribbean / Isabelle Adam, Mihály Fazekas, Nóra Regös, Bence Tóth; technical editors, Marcello Basani, Jacopo Gamba.
p. cm. — (IDB Technical Note ; 2055)
Includes bibliographic references.
1. Water utilities-Corrupt practices-Latin America. 2. Water utilities-Corrupt practices-Caribbean Area. 3. Water-supply-Corrupt practices-Latin America. 4. Water-supply-Corrupt practices-Caribbean Area. 5. Public contracts-Corrupt practices-Latin America. 6. Public contracts-Corrupt practices-Caribbean Area. I. Adam, Isabelle. II. Fazekas, Mihály, 1983- III. Regös, Nóra. IV. Tóth, Bence. V. Basani, Marcello, editor. VI. Gamba, Jacopo, editor. VII. Inter-American Development Bank. Water and Sanitation Division. VIII. Inter-American Development Bank. Innovation in Citizen Services Division. IX. Series.
IDB-TN-2055
JEL Code: Q01 Q25 Q56 N56 D73 L95
Key words: water and sanitation, integrity, transparency, corruption.
Editing: Julie Schwietert Collazo.

The authors and technical editors wish to thank the IDB's Water and Sanitation Division (WSA) and the IDB's Innovation in Citizen Services Division (ICS). Particularly, we extend our appreciation to Sergio Campos, Lea Gimenez, Roberto de Michele, Francesco de Simone, Kleber Machado, Anastasiya Yarygina and Sheila Grandio.

We are pleased to offer special recognition to a unparalleled group of reviewers: Tina Soreide, Maria Trinidad Inostroza, Juanita Riaño and Ana Maria Calderon. We also acknowledge the key contribution of the Government Transparency Institute and the Water Integrity Network. In particular, Umrbek Allakulov has provided invaluable insights.

This document was developed with the support of the AquaFund and the Transparency Fund.

The AquaFund is an IDB thematic fund for water and sanitation, the main financing mechanism to support the Bank's investments in the sector since its creation in 2008. The AquaFund is financed with the IDB's own resources and with resources from donor partners: the Government of Austria, the Spanish Agency for International Development Cooperation (AECID), the PepsiCo Foundation and Swiss Cooperation through its Agency for Development and Cooperation (COSUDE) and the State Secretariat for Economic Affairs (SECO).

The Transparency Fund, established in 2007, is the main tool available to the IDB to support technical cooperation projects and initiatives in the areas of transparency, anti-corruption and open government. The Transparency Fund is supported and financed by the Government of Canada, the Government of Italy, the Government of Norway, the Government of Sweden and the MasterCard Corporation.

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WIN Water Integrity Network
Fighting corruption in water worldwide
Government Transparency Institute
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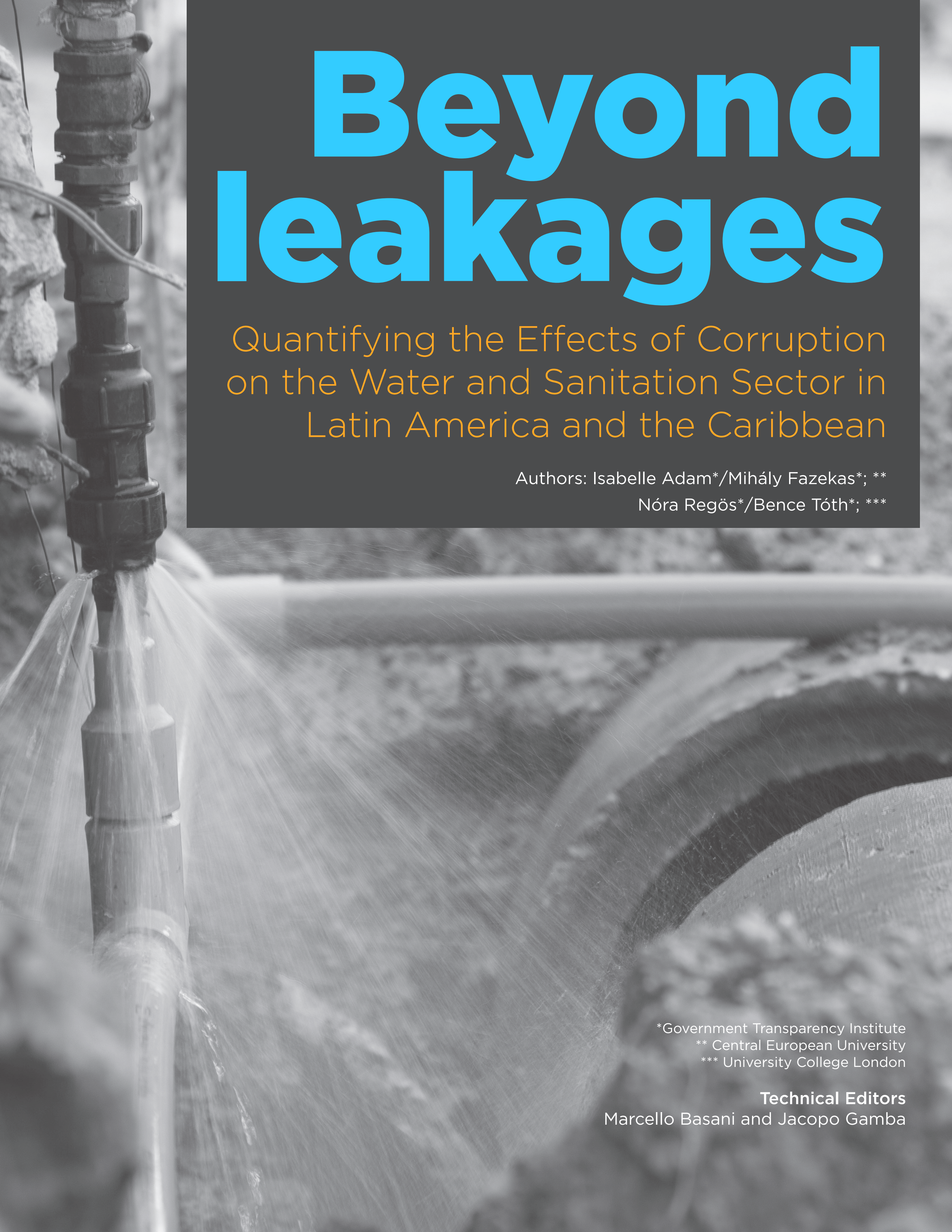

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Executive summary

The importance of transparency and governance as determinants of efficiency, effectiveness, and quality of service undoubtedly occupy a key place among the most relevant lessons learned from the reforms implemented in the Water and Sanitation sector (W&S) in Latin America and the Caribbean (LAC) in the last two decades.

In order to support data-driven policy reform aimed at increasing efficiency in public investments, the present analysis focuses on estimating direct financial costs in terms of contract award prices and direct social costs in terms of project delivery quality (measured as frequency of delays and cancellations). Given data constraints in LAC W&S, the following questions are explored by this study:

1. **What are the scale and types of corruption affecting W&S services?**
2. **What is the effect of corruption in terms of tender completion?**
3. **What is the financial impact of corruption for W&S services providers, such as high cost of infrastructure development?**

These questions were investigated using data from six LAC countries-- Colombia, Ecuador, Jamaica, Mexico, Paraguay, and Uruguay-- covering the 2006-2018 period, albeit data availability varies by country (see data section for details). Selection of countries was based on data availability and quality, while also aiming to have broad geographical coverage of the region.

In order to measure the impacts of corruption in the W&S sector, additional data was collected on two main outcome groups identified in the conceptual framework:

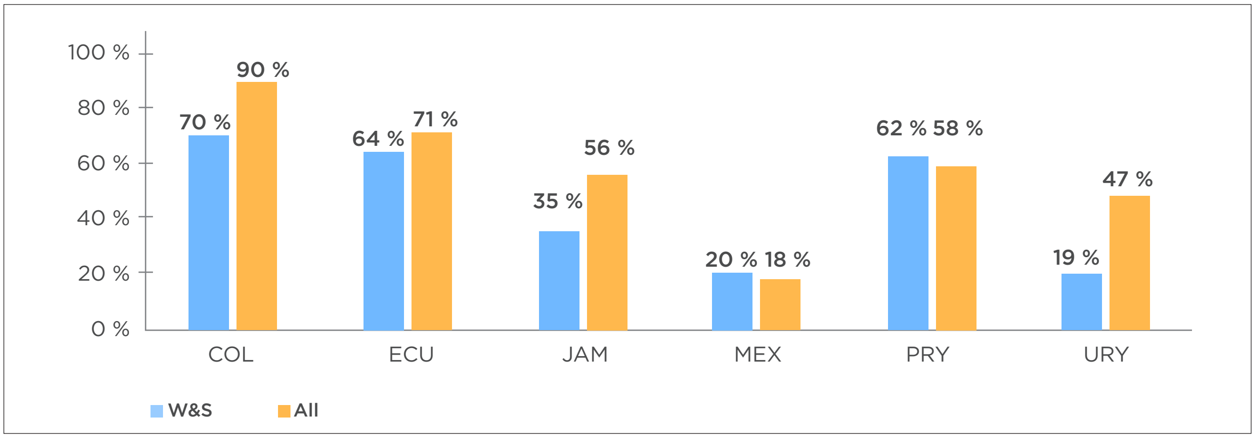
- **prices (unit prices or relative prices) and**
- **quality (delays and cancellations).**

However, each of these outcome indicators was only available in one or two countries and the datasets are of varying quality, with Jamaica having the less complete dataset and Mexico only containing federal contracts, missing local W&S contracts (this is a major shortcoming, as local water utilities are among the biggest spenders in the sector). As a result, the findings are not comparable across countries; however, considered together they give an overview of the different impacts corruption can have on financing the W&S sector.

The methodology for proxying corruption was centred on a composite Corruption Risk Index (CRI) capable of providing a comprehensive assessment of corruption risks in the W&S and other sectors. This methodology has been applied to over 40 countries around the world, suggesting its applicability to other countries in the LAC region where appropriate administrative data is available. The CRI methodology rests on identifying a range of risk factors, validity testing them and pulling them together into a composite score. Risk indicators (or red flags) considered included non-competitive, direct procedure types or single bidding. Similar to data on outcomes, the list of corruption proxies available varied per country, making direct cross-country comparisons unreliable.

Due to the varying availability of data and the range of available variables in the six countries covered, the combination of corruption risk indicators is different from country to country. In addition, the proportion of different types of contracts also differs across countries (e.g. some have far fewer construction contracts). Despite these differences, applying the same corruption risk assessment methodology provides valuable insights. For example, it is informative to compare countries according to one widely available elementary risk indicator, "single bidding", which has already been used in cross-country contexts in Europe (Fazekas & Kocsis, 2017). Figure E1 shows that while contracting risks are significantly lower in the W&S sector in Colombia, Ecuador, Jamaica and Uruguay, compared to the whole public procurement sector, the share of single bidding tenders in W&S in Mexico and Paraguay is slightly above their national averages. This finding points out the need for a further analysis in these countries to help develop recommendations improving the governance of procurement processes in the W&S sector.

Figure E1: Share of single bidder contracts in W&S sector vs. all contracts



This diversity of indicators, datasets, and regulatory frameworks provides the opportunity to identify a range of impacts in different contexts. Table E1, below, brings together the estimates for the different corruption impacts on prices and quality in the six countries, revealing that some effects are of modest magnitude, such as impact on delays, while others are major, such as impact on unit prices. Taken together and considering limitations of data and measurement, the analysis suggests that a decisive policy reform reducing risks by about two-thirds (aggressive scenario) could result in substantial savings across the sector: 7-16% of prices for standardized (e.g. chairs) as well as unique goods (e.g. pipes), and 10-19% lower incidence of cancellations and delays. While these may sound modest in percentage terms, total savings from effective anticorruption reforms are substantial, given the high value of total spending in the sector.

Table E1. Summary of estimated corruption impacts, comparative findings

Corruption impact	Corruption risk change scenario	Country basis	Impact range (relative improvement)
Prices: unit prices	Conservative	Mexico, Uruguay	Prices: unit prices
Prices: unit prices	Aggressive	Mexico, Uruguay	Prices: unit prices
Prices: relative prices	Conservative	Ecuador, Paraguay, (Jamaica)	Prices: unit prices
Prices: relative prices	Aggressive	Ecuador, Paraguay, (Jamaica)	Prices: unit prices
Delivery delay	Conservative	Colombia	Prices: unit prices
Delivery delay	Aggressive	Colombia	Prices: unit prices
Tender cancellation	Conservative	Colombia	Prices: unit prices
Tender cancellation	Aggressive	Colombia	Prices: unit prices

The following policy lessons can be offered based on the main findings of the study:

1

Public procurement data shall be improved across the region if data analytics is to be more effectively used for guiding policy. In particular, data errors and missing fields should be decreased by better enforcing procurement regulations. In addition, the scope of national public procurement datasets could be extended to cover a wider range of impacts as well as corruption risk indicators:

- Indicators of prices, both relative contract values (estimated versus awarded contract value) and unit prices (the latter is best deployed for standardized goods and services).
- Indicators of procurement results and delivery quality, such as information on project completion delays and cost overruns.
- Indicators conducive to risk assessment, such as supplier country of registration, linked sanctions list (i.e. marking debarred companies), and losing bidder's name and bid prices.

2

It is possible to develop risk assessment frameworks guiding both micro level decisions, such as audits, as well as policy reform, such as levels of oversight. Such frameworks could run on a near real-time basis, made accessible through widely available and easy-to-use analytical dashboards. Naturally, oversight institutions such as supreme audit bodies or anticorruption agencies are well-placed to implement, operate and use such risk assessment. While acknowledging the specificities of the W&S sector governance in each country of the LAC region, the study suggests that water regulators should also embrace, adopt and apply risk assessment methodologies to support stronger oversight and control of activities related to water provision – starting with procurement - and ensure greater transparency in the service.

3

It is possible and necessary to introduce public procurement cost monitoring mechanisms. This study has shown that it is feasible and fruitful to estimate the impacts of corruption on prices and quality in public procurement. Given available public procurement datasets and the methodology introduced by this study, LAC governments, especially anticorruption agencies or supreme audit institutions, could regularly track the likely costs of corruption in order to inform investments into anticorruption activities from a cost-benefit perspective, too.

4

Investing in public procurement reform is a cost-effective way to lower corruption costs. The cost of corruption estimates, while arguably imprecise, allow for gauging some of the main public losses due to corruption in the W&S sector. These estimates suggest that investing in anti-corruption reform pays off already in a narrow cost-benefit sense while further contributing to less easily quantifiable benefits such as public trust in government. Anti-corruption agencies should incorporate the presented methodology into proactive sectoral monitoring (as opposed to ex-post anticorruption mechanisms that only get activated when an illegal event is detected). This approach would support decision-makers in the W&S sector to weigh risks generated by lack of transparency in a particularly investment-intensive sector. The analysis of the impact of corruption on price and quality of public procurement might also be explored as a tool to meaningfully re-organize anti-corruption strategies and allocate resources more efficiently.

1. Introduction

From the 1990s onward several reforms were introduced in the Latin America and the Caribbean (LAC) region to improve water and sanitation (W&S) services, and, specifically, the efficiency and financial sustainability of the sector. In most countries, private companies assumed management of W&S services under the supervision of newly created, autonomous regulatory bodies that were tasked with ensuring quality standards and cost-efficiency. The sector was regulated at a central level and managed at the local level, a practice that limited the efficient operation of those entities. Overall, access to drinking water in the whole region increased from 85% to 95%, and sanitation to 81% between 1990 and 2015 (Bertoméu-Sánchez & Serebrisky, 2018). Most countries in the region use IBT (Increasing Block Tariffs) to cover costs and ensure financial sustainability of W&S services, although the design of IBT structures vary by country regarding levels of fixed and variable charges and block settings (Bertoméu-Sánchez & Serebrisky, 2018).

Among the most relevant lessons learned from these reforms in the W&S in LAC in recent decades, the importance of information management practices, transparency and governance as determinants of efficiency, effectiveness and quality of service undoubtedly occupy a key place.

This research aims to help understand and improve governance of the W&S sector using a range of indicators to measure corruption-related losses in order to calculate the negative effects of mismanagement and crimes that affect the full enjoyment of the human right to W&S. The focus is on identifying the scope and key areas of corruption losses, which will hopefully pave the way for further analysis into the drivers of such costs and the design of better policies, thereby improving access and quality of service.

The overarching goal of the research is to estimate the economic and social costs of corruption in the W&S sector in Latin America and the Caribbean using administrative data, objective indicators and a transparent, replicable methodology. This goal gives rise to a wide range of research questions that can be answered with the help of data on quality of W&S infrastructure delivery and social impacts (e.g. number of pipe breaks, population coverage of drinking water, utilities' speed of response to requests or damages, or costs of utility services for households). However, it was found that across LAC there are only very scattered information and datasets on such characteristics. Driven by data availability constraints, the main dataset analyzed in this report is public procurement data in the W&S sector for 2006-2018.

The analysis focuses on estimating direct financial costs of corruption in terms of prices and direct social costs in terms of project delivery quality (delay and cancellation). Delivery delay reflects the eventual project length measured in days in relation to the expected project duration at contract award. Tender cancellations are the absolute number of cancelled tenders not reaching contract award stage.
While a broader set of questions would have been interesting to explore, the questions highlighted below are those that were traceable given the data currently available in LAC W&S:

1. **What are the scale and types of corruption affecting W&S services?**
2. **What is the effect of corruption in terms of tender completion?**
3. **What is the financial impact of corruption for W&S services providers, such as high cost of infrastructure development?**

These questions were investigated on data for six LAC countries: Colombia, Ecuador, Jamaica, Mexico, Paraguay, and Uruguay, covering the 2006-2018 period. Note that data availability varies by country (see data section for details). Selection of countries was based on data availability and quality, while also aiming to have broad geographical coverage of the region.

The report is structured as follows: section 2 sets out the conceptual framework underpinning the methodology in section 3; section 4 presents the data sources screened and selection of countries for the analysis; section 5 discusses results for each of the six countries investigated; and section 6 brings together the country findings to draw broader, policy-relevant conclusions.

2. Conceptual framework: The types of corruption costs in W&S

The focus in this section is on defining key terms and enumerating the main cost types directly influenced by corruption. The second-order, systemic impacts, as well as the specific impact mechanisms of corruption, fall outside the empirical scope of this study; thus, the conceptual framework leaves them aside. Other comprehensive studies discuss these in greater depth, such as OECD (2015).

Throughout this study, the W&S sector refers to activities related to water and sanitation services, both on the input and output sides of the production process. That is, inputs purchased by W&S utilities, such as construction works or office supplies, are considered within the study scope, as is the actual provision of final outputs demanded by users, such as freshwater. Corruption is defined as a deliberate restriction of open, fair, and impartial allocation of public resources to the benefit of those with connections, to the detriment to outsiders without such ties (e.g. family, friendship or bribery-based) (Mungiu-Pippidi, 2006; North, Wallis, & Weingast, 2009; Rothstein & Teorell, 2008). This definition is arguably broader than most criminal law definitions but falls close to popular understandings of violating government impartiality. It is also the definition adopted in one form or another by a range of international organizations, such as the World Bank (World Bank, 2009).

Literature on corruption in the W&S sector is scattered and often relies on perception-based indices. Such measurements are often inadequate in this context as the general population or experts have very little direct experience with the development of infrastructure such as W&S and can observe corruption in it to a limited degree (Kenny, 2006; Olken, 2009). Nevertheless, based on the available theoretical and empirical evidence on the W&S sector and public infrastructure provision in general, key expectations can be drawn about the costs of corruption in W&S.

Generally, investment in the provision of public W&S infrastructure and services is thought to be particularly prone to corruption (Anbarci, Escaleras, & Register, 2009; Kenny, 2007). Investments in this sector often involve large flows of public money, as W&S is more than twice as capital-intensive as other utilities. Large water management, irrigation and dam projects are complex and difficult to standardize, making procurement lucrative and manipulation difficult to detect (Transparency International, 2008). In the public investment cycle, corruption can occur at any phase -- from planning, to the tendering process, or contract implementation -- inflicting different costs on societies and implying different mitigation strategies (Benitez, Estache, & Soreide, 2010; Kenny, 2006, 2009). Each phase is conducive to corruption.

Putting an exact financial cost on corruption in the W&S sector is difficult. While a best-case scenario might suggest that 10 percent is being siphoned off from the sector annually in corrupt practices, a worst-case scenario places the figure at 30 percent (Transparency International, 2008). At the global level, different estimates of the quantifiable damage that corrupt and dishonest practices cause to the W&S sector have been based on proxies. Davis (2004), for example, finds that "it is not unreasonable to think that these institutions [public agencies and W&S service providers in South Asia] regularly spend 20-35% more on construction contract surcharges for diverting part of their resources in search of favours or providing free services or illegal connections to households." As a general figure, it is estimated that in developing countries, corruption can increase by 30 percent the cost of obtaining a connection to the water and sewerage network. Although there are no reliable estimates of total losses, Water Integrity Network (2016) reports that every 10% of investment in the water sector lost to corruption involves over US$75 billion in annual losses to the sector worldwide.

In consequence, corruption in this sector imposes a social cost and constitutes a barrier to public health and the development of nations. Furthermore, W&S sector corruption corrodes public institutions and causes the loss of legitimacy and credibility of the State in the eyes of citizens. In addition, corruption threatens the achievement of the Sustainable Development Goals (SDGs), and has a negative impact on the realization of humans' right to safe drinking W&S (Baillat, 2013; Davies & Fumega, 2014; Davis, 2004; Transparency International, 2008; Water Integrity Network, 2016). More precisely, corruption in the provision of W&S infrastructure can compromise public goals in at least three direct ways: 1) distorting spending structure and project design; 2) inflating public procurement prices for a given quality; and 3) contributing to delayed and low-quality provision, and -- in extreme cases -- non-completion. Each of these are reviewed briefly in order to provide context for the subsequent empirical analysis.

1

First, corruption in the W&S sector is likely to distort the public spending structure, in particular biasing public investment toward high-value, high-complexity investments into new infrastructure, as opposed to spending on maintenance and operations. In high-value projects, even a small fraction of the investment value amounts to large corruption rents, making them particularly attractive (Rose-Ackerman, 1999; Transparency International, 2008). This expected distortion is demonstrated by Tanzi and Davoodi (1997), who show that a higher level of perceived corruption in a country is associated with increased public investment, but with lower expenditures on operations and maintenance. Fazekas, Lukács, and Tóth (2015) point out that while the highest value and highest corruption risk procurement tenders are in infrastructure provision in Hungary, the average corruption risk of the sector is not particularly high. Their findings suggest that at least some of the focus on corruption in public infrastructure may be driven by salient cases rather than a solid understanding of the overall risk profile of sectors. Given these considerations, it should be investigated to what degree corruption biases W&S spending toward high value projects in Latin America and the Caribbean. Unfortunately, currently available datasets for countries included in this study are too limited to measure changes in spending structure.

Second, corruption in public W&S provision is likely to increase procurement prices. Price inflation can manifest itself in wages or material costs in the awarded contract or only later during contract implementation. Duflo (2003) shows that overpricing is one main mechanism to extract rents from public works on water irrigation systems in India. Flyvbjerg, Skamris Holm, and Buhl (2004) also demonstrate that cost overrun is strongly affected by the length of the implementation phase, undescoring the connection between costs and implementation period (see below). Evidence from Italy contrasting data on cumulative investment into infrastructure and its available stock shows how region-level corruption in infrastructure positively correlates with the price of infrastructure, even after controlling for input costs, such as labor or construction material prices (Golden & Picci, 2005). While percentage price differences might appear small, given the high value of many W&S infrastructure projects, the absolute costs are high (Water Integrity Network, 2016). This literature suggests that the effect of corruption on prices of public W&S investments should be explored empirically, as is the case in this study.

Third, there seems to be a correlation between higher incidence of corruption and increased delays and low-quality provision of W&S infrastructure and services. In this scenario, the corruption rent for the corrupt network is extracted by providing infrastructure or services of lower quality than contracted or delaying the works, which leads to cost overruns, as mentioned above. This connection between corruption and low-quality and delays in the W&S sector is indirectly established by Blancas, Chioda, Cordella, Oliveira, and Várdy (2011), for example. In order to evaluate the effects of an anti-corruption reform aiming to reduce delays in public works implementation, they compare the procurement performance of the largest water and sewage utilities in São Paulo state (a reformer state) and Minas Gerais (a non-reformer state). The analysis finds that the reform is associated with a 24-day reduction in the duration of procurement processes for large projects. Interestingly, however, they find no evidence of an effect on prices paid (Blancas, Chioda, Cordella, Oliveira, & Várdy, 2011).

Flyvbjerg et al. (2004) point out that delayed provision and long implementation also create ideal conditions for inflating costs. Weak supervision and enforcement of the initial contracts give rise to corruption risks, and while construction delays are easy to detect, assessing implementation quality is less straightforward (e.g. effects are only visible after years). Nevertheless, low quality and time overruns are not straightforward proxies of corruption, as complex projects can have unforeseen complications. The example of a report for the One WASH National Program in Ethiopia shows that most companies bidding for public contracts submitted bids without fully understanding the work or making a site visit and bid a very low price to win contracts, leading to low quality and delays (Defere, 2015). This ambiguity suggests that the effect of corruption on delays and quality of W&S provision in terms of percentage increase or total amount increase should be explored empirically.

While these different forms of direct corruption costs in the W&S sector may occur jointly or substitute for each other, they are likely to carry different social costs. If corruption only increases the price of services or infrastructure without impacting project design, quality, delivery time, or overall completion, total social cost would be close to the direct cost. However, if corruption's direct impact goes beyond prices, additional indirect costs are likely inflicted on the society, such as non-available W&S infrastructure or unreliable provision, which can pose serious risks to human health. These issues cannot be discussed in detail, as their measurement is beyond the framework of this study. Nevertheless, this short discussion aimed to clarify that the relationship between corruption and inefficiency is complex and depends not only on the amount, but also on the type of corruption occurring. Corruption causes larger and smaller inefficiencies, while broader inefficiencies may occur without corruption, too.

3. Methodology

3.1 Measuring corruption

While there is a lot of controversy over how best to define corruption (Johnston, 1996), a definition specific to the domain of public procurement was adopted following from our general definition of corruption from above. In addition, the chosen definition is backed up by legal and governance principles (Rothstein & Teorell, 2008) and widely used by practitioners around the globe: *In public procurement, the aim of institutionalized corruption is to steer the contract to the favored bidder without detection in a recurrent and organized fashion* (Fazekas & Tóth, 2014; World Bank, 2009). This requires at least two violations of principles of impartial distribution of public resources: 1) avoiding competition by, for example, using unjustified sole sourcing or direct contract awards; and 2) favoring a certain bidder by, for example, tailoring specifications, or sharing inside information. This definition of corruption focuses attention on restricted access to and unfair competition for public resources (Mungiu-Pippidi, 2015; North et al., 2009). Crucially, this definition based on social science conceptions of corruption may well deviate from criminal law concepts in each of our case study countries, which are themselves different from each other and vary over time. It is necessary to use a sufficiently encompassing and, broadly speaking, comparable definition of corruption for the subsequent analysis in order to advance measurement using a comparable methodology across countries (Mungiu-Pippidi & Fazekas, 2020). Hence, this definition allows for developing proxy indicators of corruption, or corruption risk indices, which approximate -- but do not directly measure -- corrupt transactions in public procurement.

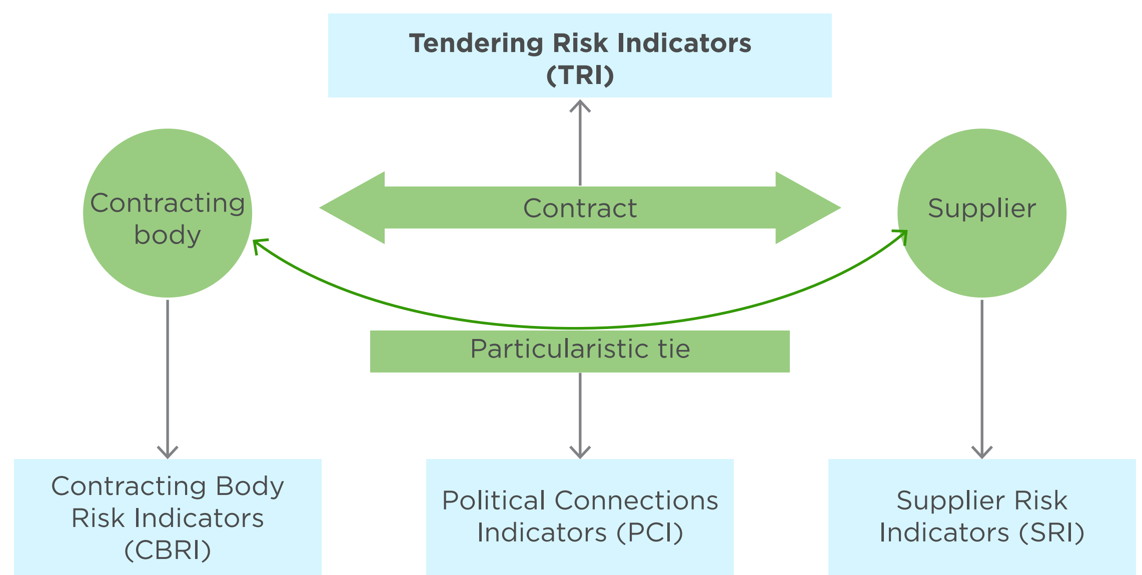
Restricted and unfair access then translates into higher prices, lower quality and quantity in order to generate corruption rents. Such rents may be extracted in the form of bribes, but it is more typical to channel rents through broker firms, subcontracts, offshore companies, and bogus consultancy contracts -- to name a few typical instruments. As public procurement and, especially, infrastructure delivery involve huge sums, the typical institutionalized corruption scenario involves elites from both the public and private sectors, such as elected officials, high-level bureaucrats, and wealthy businesspeople. The measures of corruption risk used in the present study are drawn from the above definition and follow work of the authors elsewhere discussed extensively, with respect to both single country and cross-country analyses (Charron, Dahlström, Fazekas, & Lapuente, 2017; Fazekas, Chvalkovská, Skuhrovec, Tóth, & King, 2014; Fazekas, Tóth, & King, 2016)

The measurement approach exploits the fact that for institutionalized corruption to work, procurement contracts have to be awarded to companies belonging to the corrupt network. This can only be achieved if legally prescribed rules of competition and openness are circumvented. By implication, it is possible to identify the input side of the corruption process -- that is: fixing the procedural rules for limiting competition – as well as the output side of corruption -- that is: signs of limited competition. By measuring the degree of unfair restriction of competition in public procurement, a proxy indicator of corruption can be obtained.

Specifically, analyzing the process of awarding contracts and key outputs -- such as number of bidders and market concentration -- is proposed. Crucially, lack of bidders for government contracts (single bidder) is an outcome of the corruption-prone procurement process; whereas, the introduction of certain procedural rules for limiting competition (manipulating procedure types and shortening advertising period) are inputs. The relationships among biases in the tendering process (inputs) and single bidding (outputs) form the measurement model, and can serve as a validity test when selecting proxy indicators for constructing a corruption risk index.

Any form of corrupt contract allocation thus requires at least four components to be in place: a) corrupt transactions allowing for rent generation (contract); b) corrupt relations underpinning collective action of corrupt groups (particularistic tie); c) organizations enabling rent allocation (contracting body); and d) organizations extracting corrupt rents (supplier). These four components serve as a framework for risk assessment, leading to four types of indicators, which are illustrated in Figure 1 below.

Figure 1. Components of the corrupt exchange and corresponding indicator groups



Note: green denotes components of the corrupt scheme: blue marks the indicator groups.

Source: Fazekas & Cingolani (2016)

In each of these groups, there exists a wide array of elementary corruption risk indicators that derive from proven cases while also being validity tested on large-scale datasets (for a full discussion, see Fazekas & Cingolani, 2016). **Tendering Risk Indicators** capture all those micro-level aspects of public procurement tenders and contract implementation that signal corrupt manipulation of the procurement process in order to generate rents and allocate them to the connected companies. A particularly widely quoted example is the tailoring of tender conditions in any phase of the public procurement process to fit a single company on an otherwise competitive market. **Political Connections Indicators** provide cues on the particularistic ties (e.g. through kinship, friendship, professional) between bidder's managers and political office holders who are able to influence the public procurement process. Such ties are indispensable for monitoring and enforcing corrupt deals, which tend to be informal. Some of these types of personal connections are difficult to measure while others are established as institutionalized forms of connections, such as political party finances (OECD, 2014) or lobbying (David-Barrett, 2011).

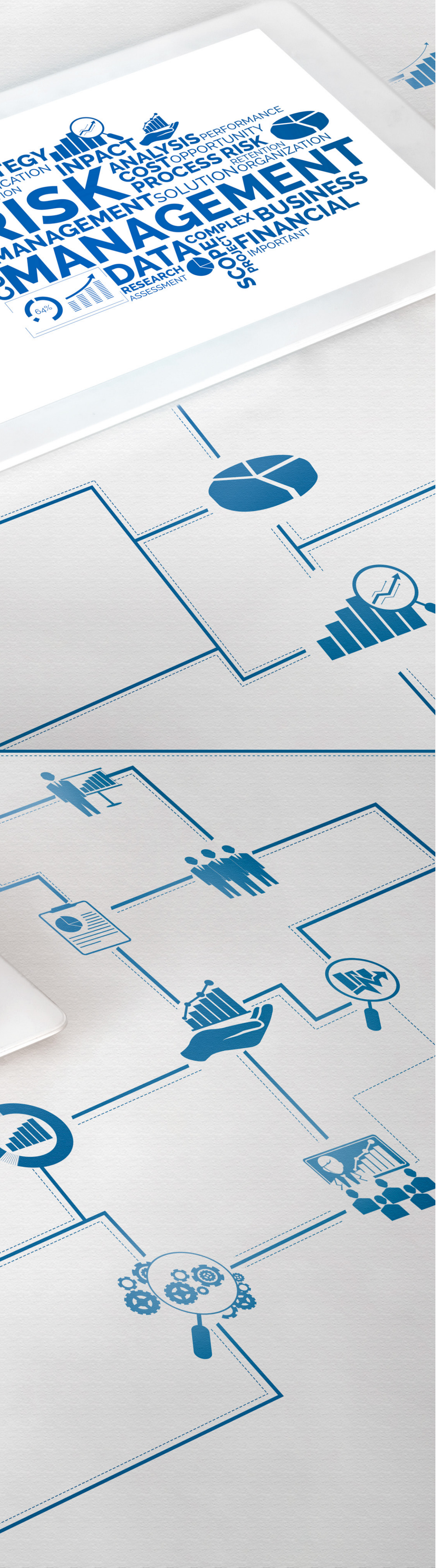
Supplier Risk Indicators signal the use of winner companies as vehicles of rent extraction and the distribution and hiding of assets. Identifying corrupt companies based on publicly available data is an inherently challenging exercise; thus, companies are evaluated on multiple dimensions: company registry attributes, company financial information, company ownership and management data, and company governance information. **Contracting Body Risk Indicators** capture the risk of corrupt allocation of public funds by contracting bodies and weaknesses of formal bureaucratic structures designed to shield contracting bodies from pressures to favor connected bidders. Various indicators aim at capturing relevant agency-level characteristics, such as transparency index scores (Williams, 2015), or political appointments and contract approval rights (Dahlström, Fazekas, & Lewis, 2018), and auditing information, prosecutions, budget transparency and controls, or asset declarations (Fazekas & Cingolani, 2016).

Table 1 below lists all the indicators (red flags) that could be calculated and validity tested in the countries covered by the study, including their definitions. Detailed explanations of all indicators used and the way they were constructed are given in the country chapters.

Table 1. **Overview and definition of red flags per country (for exact definitions please see the country chapters)**

Indicator group	Red flag	UY	MX	CO	JM	PY	EC
Tendering risk	Procedure type		x	x	x	x	x
Tendering risk	Lack of call for tender publication	x	x	x		x	x
Tendering risk	Length of bid submission period	x	x	x		x	x
Tendering risk	Single bidder contract	x	x	x	x	x	x
Tendering risk	Length of decision period	x	x	x		x	x
Tendering risk	Number of documents published		x			x	
Tendering risk	Contract modification during advertisement		x				
Tendering risk	Contract modification during implementation		x				
Tendering risk	Relative delay of project duration			x			
Tendering risk	Number of requested bids				x		
Tendering risk	Tender description length					x	
Supplier risk	Supplier registered in tax haven		x	x			
Supplier risk	Sanctioned companies		x				
Supplier risk	Same location of buyer and supplier			x			x
Supplier risk	Supplier spending share	x	x	x	x		x
Supplier risk	Winning probability					x	
Political connections	Political connections	x					

Many of the available and potentially valid indicators suffer from overestimating corruption risks, as there are numerous alternatives, non-corrupt explanations to their presence (e.g. lack of bidders in a small and geographically isolated market) (i.e. false positives). False positives, for instance, can be eliminated by carefully parametrising and selecting the elementary risk indicators that are most closely associated with other corruption signals: that is, to triangulate risk indicators against each other, keeping only those indicators that fit a corrupt rent extraction model. False positives can be further eliminated by pulling validated indicators from different indicator groups into a composite score, the Corruption Risk Index (CRI), which becomes more robust to unobserved variation in specific corruption techniques and measurement error. Nevertheless, false positives certainly remain, warranting the use of risk indicators rather than direct measurement of corruption. Moreover, as with any measurement



framework, this methodology can only capture those types of corruption risks for which there is publicly available, structured data. There can be numerous instances of corruption-prone procurement where red flags are not measured but in which corruption may still exist (that is false negatives). For example, information on the quality of the delivered products is usually not part of the central public procurement systems (quality of material used, durability of items); hence, such corruption risks specific to contract delivery are harder to detect with the methodology used in this study.

The most straightforward way of parametrising and validity testing elementary indicators is to analyze their fit with our corruption definition. For example, it can be verified that a short advertisement period predicts single bidding on competitive markets because short advertisement is frequently used to limit competition to the favored firm (Fazekas et al., 2016). In addition, those ranges of advertisement period lengths (number of days) can be also identified, which are the strongest predictors of single bidding compared to typical or average advertisement period lengths. This allows for identifying thresholds beyond which corruption risks are likely to increase substantially. In general, regression analysis is used to identify 'red flags,' which are most likely to signal corruption, and to assign the values of variables, such as advertisement period length, or procedure types to groups of high, medium and low corruption risk. The number of corruption risk categories can vary between two (low risk vs. high risky) and three (low, medium and high risk). The number of risk categories in any country and risk factor is determined by their regression fit, i.e. we aimed to coarsen risk information while retaining explanatory power. Please also note that the risk category definitions (e.g. the number of advertisement days below which we assigned high risk to a tender) may well deviate from national or international regulations (e.g. the time limit for advertisement defined by national law). This is because regulations may be imperfect, in some cases themselves corrupt or simply implemented incorrectly; hence, the analysis has to rely on observed actor behavior for defining risks rather than on laws and regulations.

Ultimately, those variables are selected that are large and statistically significant predictors of single bidder contracts, which is the simplest sign of lack of competition. The regression set-up controls for a number of likely confounders of bidder numbers, for example: (1) institutional endowments measured by type of buyer (e.g. municipal, national); (2) product market; (3) contract size (log contract value); or (4) regulatory changes as proxied by year of contract award. Regressions are run for each country separately in order to best capture national specificities of corruption technologies and institutional endowments.

Combining the validated elementary risk indicators, a composite score of tendering 'red flags', called **Corruption Risk Index (CRI)**, is developed**,** as an objective proxy measure of high-level corruption in public procurement that operationalizes the previously described definition of corruption, derives from objective public procurement data, allows for consistent comparisons across time and organizations, and can be further validated using alternative corruption proxies (for a detailed explanation of CRI building, see Fazekas and Kocsis (2017)). For simplicity of interpretation, the CRI is composed as a simple arithmetic average of individual risk indicators, such that all red flags have the same weight within each country. In addition, the standard CRI is scaled to fall between 0 and 1, with 1 representing the highest observed corruption risk and 0 the lowest. Please note that for the ease of interpretation, a version of the CRI scaled to one unit representing one red flag will be used. For example, if a country has nine red flags, then its modified scale CRI will run between 0 and 9. The composite corruption risk indicator approach is most suitable for studying the cost of corruption as it averages across different types of risks without relying on hypotheses as to which type is more costly than others. This means that we estimate cost impacts of the composite CRI only without differentiating the impact by specific red flags.

3.2 Measuring the impacts of corruption

In order to measure the impacts of corruption in the W&S sector, we aimed at collecting data on all three main outcome groups identified in the conceptual framework: spending structure, prices and delivery quality. Unfortunately, due to data limitations, only two of those outcomes (Table 2) could be reliably tracked:

- **prices (unit prices or relative prices) and**
- **quality (delays and cancellations).**

Unit price refers to the standardized average price for a certain quantity of a product of a work or service to be performed and it is calculated as the ratio between the total contract value and purchased quantity (Oliveira, Fabregas, & Fazekas, 2019). Relative price is defined as the final contract (or tender) value divided by the initially estimated price, which essentially captures the discounts companies offer compared to the reference price (Coviello & Mariniello, 2014). Depending on the available price data in each country, either unit or relative prices were used. However, it must be noted that neither of these variables are without their shortcomings, so they should ideally be used in conjunction. Unit prices are only reliable for standardized goods and services, but not for unique products like most construction works. Hence, unit prices were only looked at for goods. Relative prices, while applicable to a broader range of products, may be biased by the variability in initial cost estimates, which can be manipulated or simply unreliable.

Quality was proxied by relative contract delivery delays and tender cancellations. Relative delivery delay is measured by dividing the eventual number of days for contract completion by the originally planned number of days for contract completion. This indicator is measured in relative rather than absolute terms (days) because contracts have vastly different timescales, ranging from a few months to several years, so an extra day of delivery on its own can be interpreted in many different ways. Tender cancellation is a binary variable, taking the value of 1 when the tender is cancelled and no contract is awarded; otherwise, it is 0.

Table 2. Overview of corruption impacts traced (dependent variables per country)

Indicator group	Corruption impact	UY	MX	CO	JM	PY	EC
Prices	Unit prices	x	x				
Prices	Relative prices					x	x
Quality	Relative delivery delays			x			
Quality	Cancellations			x			

The analysis largely follows Fazekas and Tóth (2018), but extends on their framework by incorporating quality-related outcomes. While a comprehensive identification of causal effects is beyond the scope of this report[1], the analysis relied on strong theory as outlined above, detailed and comprehensive data, and a careful modelling of non-linear relationships in order to get a reasonable approximation of the cost of corruption in the W&S sector in LAC. At a generic level, the following equation was estimated:

Corruption impact = B0 + B1*corruption risk score + B2*institutional and market controls + ε

Corruption impacts refers to the four different outcome variables defined in Table 2. Corruption risk score refers to the various composite risk indicators in each country as outlined above and fully specified in the country sections. Linear, second and third order polynomials were systematically tested to find the best model capturing non-linear relationships between risks and outcomes. For example, the hypothesis can be that beyond a certain level of risk, prices barely increase, as "things cannot really get worse". Institutional and market controls also differ from country to country, but generally include year, market, contract value, and buyer characteristics such as type or location. The exact variable descriptions are contained in each country section below, while full regression results are reported in the appendix.

1 In particular, the simple linear regression approach used may be prone to endogeneity bias. For example, it may be the case that an unobserved factor, such as product specificity, simultaneously drives both high prices and a high incidence of corruption red flags.

Our goal is to find the best regression model predicting corruption impacts, that is identifying the regression specification with the highest explanatory power and all main predictors in line with theoretical expectations. After this, the best model can be used to predict hypothetical outcomes under different anticorruption scenarios, that is different degrees of changes to corruption risks in the W&S sector. Two intuitive scenarios were kept similar across all the countries:

i) **conservative scenario:**
   This scenario assumes a moderate reduction of average corruption risks across the W&S sector (about 1/3), taking the LAC country to CRI levels similar to Mediterranean EU countries such as Greece or Italy;

ii) **aggressive scenario:**
   This scenario assumes a radical restructuring and a large reduction in corruption risks (about 2/3), taking the LAC country to CRI levels similar to Scandinavian EU countries such as Denmark or Sweden.

The purpose of differentiating these two scenarios is to give a sense of what moderate and radical reform could achieve in the given context so that policy makers can assess potential payoffs to different reforms.

4. Data

For a number of countries in Latin America and the Caribbean, the available data sources were mapped —their location, content, and ways of obtaining them— to assess their strengths and weaknesses for three distinct types of data:

- **public procurement data**
- **W&S utility performance data**
- **data on W&S infrastructure from national statistical offices**

The following long list of countries was screened in order to identify the most suitable six case study countries that will be subject to detailed analysis. Selection of the shortlisted countries was based on the scope and quality of the relevant datasets and the geographical balance of the sample.

1. Mexico
2. Colombia
3. Paraguay
4. Chile
5. Jamaica
6. Costa Rica
7. Ecuador
8. Peru
9. Brazil
10. Uruguay

First, regarding public procurement data, all of the countries have publicly available data – in the first five cases, data had been already collected and analyzable datasets had been created in prior research[2]. For the latter five countries, only the publicly available data was assessed using national public procurement websites. Only data relevant for the W&S sector was considered, that is either inputs purchased by utilities (e.g. office supplies or pipes) or outputs sold (e.g. fresh water). For each country, we therefore identified whether the public procurement data contained the relevant organizations belonging to the W&S sector or purchases related to the W&S sector (the specific terms used for searching for organizations and products are listed in the country sections below). As procurement rules and the ownership of water utilities differ by country (public vs. privatized utilities) the amount and coverage of data on the W&S sector differs considerably by country. In addition, the availability of variables needed for corruption risk indicators, corruption impacts, and control variables was assessed. On this basis, Costa Rica, Brazil, and Chile had to be excluded, as the public procurement datasets contained no or barely any utility companies as public buyers. Peru was also excluded due to the low data quality compared to the other countries available. The details of the available procurement data per country are provided in the beginning of each country chapter.

Second, in terms of utility performance data, two data sources were examined. First of all, the database of the International Benchmarking Network for W&S Utilities (IBNET)[3] compiles and shares a set of core cost and performance indicators of utilities worldwide in order to allow for international comparison of utilities' performance. These include indicators such as statistics on pipe breaks, water network coverage, service continuity, tariffs, or water quality, for example. The IBNet indicators for the chosen countries were mapped and the overlap of the IBNet data was assessed with the public procurement datasets. Unfortunately, we had to conclude that there are no or only very small overlaps because of different time periods. Specifically, the IBNet database mostly contains time series from the first decade of the 2000s while most of the public procurement datasets only cover recent years.

2 http://redflags.govtransparency.eu/
3 https://database.ib-net.org/DefaultNew.aspx

As a second data source on utility performance, it was explored whether the national utilities publish additional relevant data, such as water quality measurements of population coverage, on their websites. The only source offering utility performance indicators with a time series of more than two years were the Transitional Performance Indicators 2014-2019[4] of the Uruguayan national utility company (Obras Sanitarias del Estado). It publishes a report twice per year with statistics on complaints, new works, number of connections, number of disruptions, water loss, service coverage, water quality, and customer satisfaction. This data was used as background information but was not part of the regression analysis as its resolution was insufficient (i.e. it related to an annual country averages rather than to specific W&S services in particular towns).

Third, supporting data from each country's national statistical office were identified and mapped. For three of the six case study countries, namely Mexico, Jamaica, and Peru, the national utility's population coverage in terms of delivering water as background information could be collected; however, the data could not be directly entered into the regressions due to insufficient resolution (i.e. once again, country-level data is too disaggregated to be incorporated into a contract-level dataset).

As a result of this comprehensive data mapping and collection activities, the focus of the analytical work was on contract level datasets of public purchases in the six countries. However, even in this relatively narrow domain, the datasets of the six countries showed considerable differences in terms of scope, quality and key variables covered (Table 3). Of the highest quality were public procurement datasets of Ecuador and Paraguay and, to some degree, Uruguay. Crucially, as a result of all these differences, we explicitly refrain from ranking countries either on corruption risks or corruption impacts. Instead, the range of countries taken together shows the diverse impacts corruption can have in the W&S sectors of LAC countries. Nevertheless, it must be noted that the selected countries do not necessarily represent the full set of LAC countries, especially as they were selected based on data availability, scope and quality.

4 http://www.ose.com.uy/empresa/benchmarking

Table 3. Overview of data availability per country

	Uruguay	Mexico	Colombia	Jamaica	Paraguay	Ecuador
Years covered	2015-2018	2012-2018	2011-2018	2006-2018	2010-2018	2013-2017
Number of observations	591,663	1.4 million	2.3 million	141,317	540,537	2 million
Number of contracts/bids related to the W&S sector	12,673	30,884	72,234	375	4,840	25,513
Number of red flags	7	11	9	7	9	7
Corruption impacts tracked	Unit prices	Unit prices	Delays; Cancellations	N.A.	Relative prices	Relative prices

5. Country by country analysis

5.1 Uruguay

Data description

In 2004, access to drinkable water and sanitation as a basic human right was included in the Uruguayan constitution, followed by the National Water Plan (***Plan Nacional de Aguas***) in 2010. Water and sanitation services are provided across the country by the state-owned national utility agency, Administración de las Obras Sanitarias del Estado (OSE). In the capital, Intendencia de Montevideo provides sewerage. Just over 95% of the population has access to drinkable water through water networks and 99.2% to basic sanitation (Maroñas et al., 2020).

The Uruguayan dataset is comprised by four different sources of information. The national procurement agency (***Agencia de Compras y Contrataciónes del Estado***, ACCE) provides a database on its website listing details for tenders and contract awards from 2015-18, including most of the important variables for corruption risk analysis. The ACCE database contains roughly 655k awards from 226k unique tenders. However, the final sample size used for the CRI calculations shrank to 591,663 due to the filters applied: selecting only awarded, active or completed tenders from the period of 2015-2018. ACCE covers procurements of national, regional, local bodies, independent agencies, and armed forces.

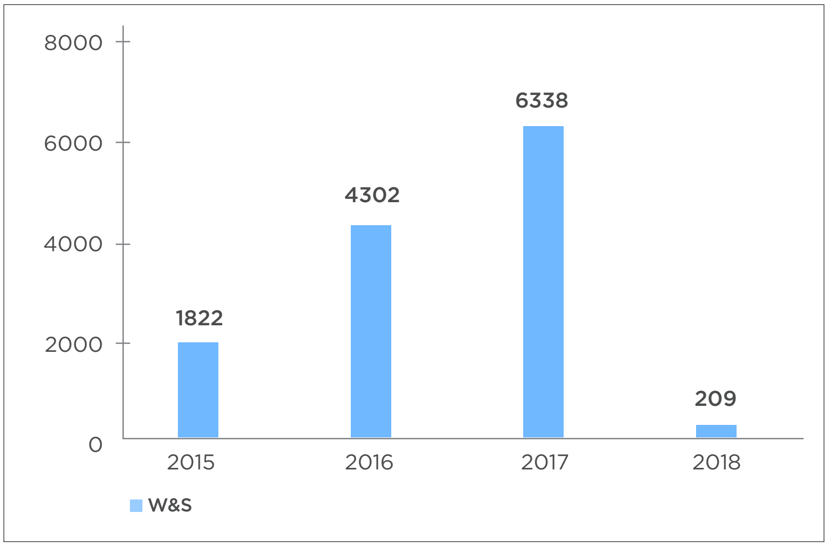
In order to broaden the scope of the dataset, information was added from three other databases. First, the Unique Register of State Suppliers (*Registro Único de Proveedores del Estado*, RUPE) includes information of supplier companies, their legal representatives, and whether they were sanctioned, for example, during the 2013-2018 period. Second, the Central Bank of Uruguay (Banco Central de Uruguay, BCU) publishes a list for the years 2015-2017 (June) of politically exposed officials, including the names of those who perform or have performed high-level public functions in the country or abroad in the last five years or who have had executive roles in an international organization. Third, the Project about Political Financing (Proyecto sobre Financiamiento de Partidos) has published a list of companies, including supplier name and tax ID, that have donated to political parties for their election campaigns. These three additional datasets were merged with the ACCE core database whenever a match using key variables was possible.

On the basis of this combined national dataset, the contracts related to the W&S sector were marked in two ways. First, the list of names of Uruguayan W&S utility companies provided by IBNet (the International Benchmarking Network for Water and Sanitation Utilities) was used and the matching buyer names were marked in the procurement dataset. In addition, buyer names were searched for a number of keywords related to W&S to complete the list of relevant buyers with, for example, local utilities that were not included in the IBNet list. The keywords tried to capture the different dimensions of the W&S sector, such as drainage, sewerage and water systems. To find the most relevant utilities and products, buyer names and product descriptions were harmonized (accents, whitespaces were removed, text converted into lower case). The keywords used for the buyer names in the Uruguayan dataset include: *"obras sanitarias" and "agua".*

Secondly, a range of keywords was used to search product descriptions in the procurement dataset in order to mark those contracts that are also related to the W&S sector. The keywords used include: "sistema de agua", "servicio red" and "agua", "saneamiento" and "conexiones", "constr" and "agua", "cuenca", alcantarillado" and "agua", "tuberias" and "agua", "canal" and "agua", "sistemas de abastecimiento" and "agua".

The number of contracts marked according to these two methods amounted to 12,673, including all contracts specifically related to W&S products based on the product description (around 146 contracts) and all contracts of W&S utility companies (12,527 contracts). The main national utility company is the Obras Sanitarias del Estado, which accounts for most of the contracts. As there is a very small difference between contracts related to W&S utility buyers versus the ones that could be marked as W&S related (see Figure 2 below), only estimations for the utility-related contracts are reported.

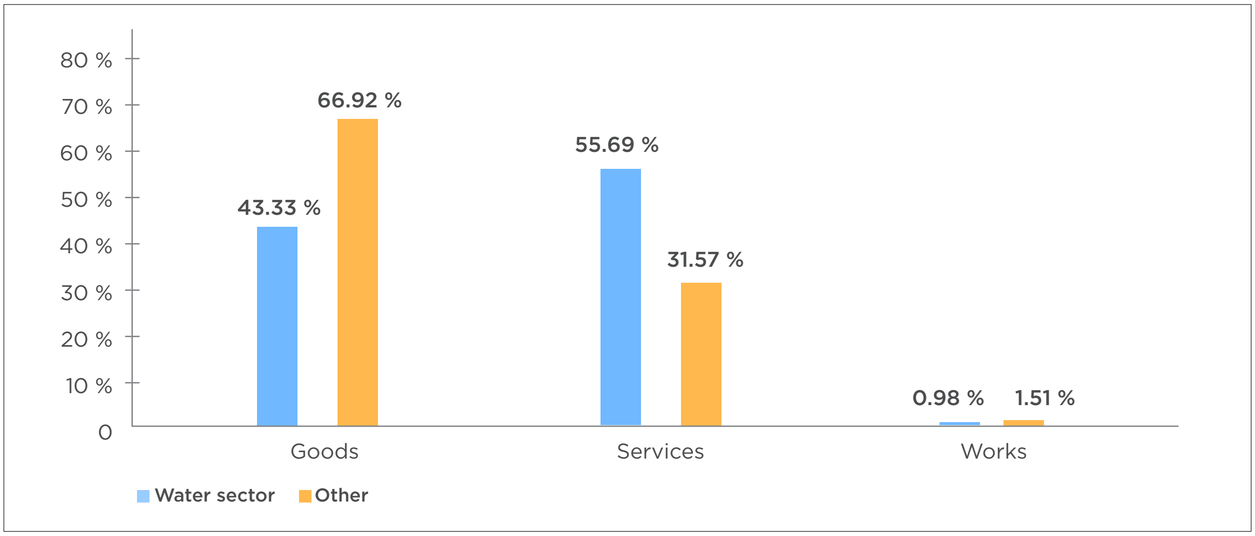
Figure 2: **Number of W&S sector contracts (Uruguay, 2015-2018)**



Note: 2018 is an incomplete year.

Most of the water sector related contracts are for services (55.7%) and goods (43.33%). The number of contracts for public works covers a very small percentage of all contracts in the W&S sector, similarly to all other sectors, as shown in Figure 3. This surprising lack of works contracts is due to the relative lack of such contracts in the source ACCE database.

Figure 3: Distribution of awarded contracts in the water sector (1) versus all other sectors (0) (Uruguay, 2015-2018)



Note: Procurement category and item classification used in SICE - Sistema de Información de Compras y Contrataciónes del Estado were used

Corruption Risk Index

A number of corruption risk indicators (red flags) could be calculated and validity tested for the Uruguayan dataset, where 0 stands for non-risky behaviour, 0.5 indicates a medium risk situation (where applicable), and 1 signifies a high corruption risk. In total, seven valid risk indicators were identified (overview in Table 4), with five of them related to the tendering process, one based on information on supplier company risks, and one indicating a political connections risk. The latter indicator is based on the BCU data on politically exposed officials. These are officials associated with the supplier who also hold or held leading political positions or another important public function. The supplier risk indicator measures whether a supplier has an extreme share in a buyer's total spending in a year.

The five tendering risks are related to different aspects of the procurement process. First, all the different procedure types used in Uruguay were classified into open and non-open procedure types based on their association with single bidding (for regression details, see Appendix F). Please note that we identify red flags (e.g. classify procedure types as non-open) based on their association with non-competitive outcomes such as single bidding in regression analysis. Consequently, the following national procedure types are considered "open": *Concesión, Licitación abreviada, Licitación pública, Llamado a expresiones de interes, PFI – Licitación pública internacional, PFI – Licitación público nacional, Pregão, Solicitud de información, Venta/Arrendamiento Licitación Abreviada, Venta/Arrendamiento Licitación Pública, Venta/Arrendamiento por Remate.* On the other hand, these national procedure types are considered non-open: *Compra directa, Compra por excepción, Convenio marco, PFI – Comparación de precios, PFI – Contratación directa, Procedimiento especial, Venta/Arrendamiento directa, Venta/Arrendamiento por excepción.* Second, not publishing the call for tenders was considered a red flag.

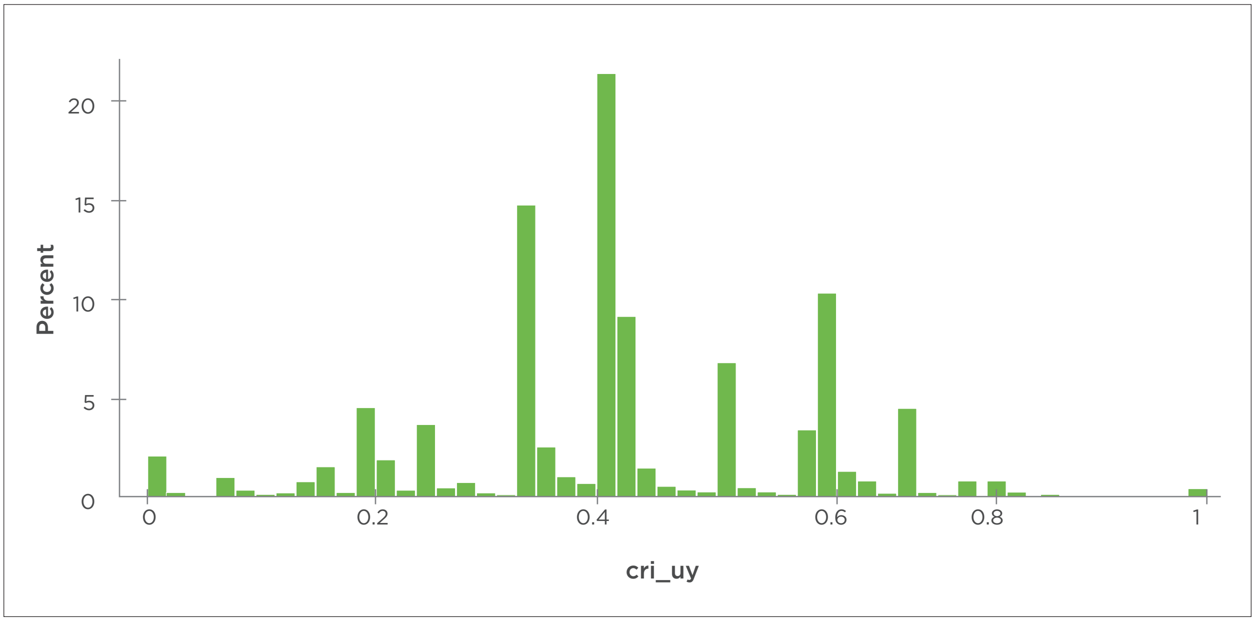
Third, the length of the period given for bid submission and the period of time it takes for the procuring body to announce a decision were measured. In the case of Uruguay, submission periods of less than 35 days are associated with a high risk of corruption, while submission periods between 36-72 days carry a medium corruption risk. For decision periods, those that are shorter than 11 days imply high corruption risks and decision periods between 12-28 days have medium corruption risk. In both cases, the exact thresholds were defined so that the risk categories predict single bidding probability the best, because we expect high risk features of the procurement process leading to restricted competition (single bidding) (see Appendix F for regression details). Lastly, a red flag was raised when there was only one bid submitted for a tender (single bidder).

Table 4. Red flag definitions, Uruguay

Indicator group	Indicator name	Indicator definition
Tendering risk	Procedure type	0 = open, competitive procedure 1 = non-open procedure (e.g. direct contracting)
Tendering risk	Lack of call for tender publication	0 = call for tenders published 1 = call for tenders not published
Tendering risk	Length of bid submission period	0 = submission period >=73 days 0.5 = submission period between 36-72 days 1 = submission period <35 days
Tendering risk	Length of decision period	0 = decision period between 29-42 days 0.5 = decision period between 12-28 days 1 = decision period <11 days
Tendering risk	Single bidder contract	0 = more than one bid received 1 = one bid received
Political connections	Political connection	0 = a politically exposed buyer is not involved 1 = a politically exposed buyer is involved
Supplier risk	Supplier spending share	The supplier's share in a buyer's total spending in a year

Having tested these 7 indicators for their validity, the composite Corruption Risk Index (CRI) was built as the simple arithmetic average of the individual risk indicators, falling between 0 and 1, with 1 representing the highest observed corruption risk and 0 the lowest. Among other things, the CRI indicator developed here allows for scoring each contract award and identifying those with the highest risk. Figure 4 shows the approximately normal distribution of risks among contract awards. In simple terms, a contract with the average CRI score has around 3 red flags out of the 7 measured red flags present. Approximately 40% of the contracts had less than 3 red flags present, more than 40% of the contracts had 3-4 red flags and only in few cases were all or the majority of red flags detected.

Figure 4. CRI distribution of contracts Uruguay, 2015-2018.



Comparing corruption risks in the W&S sector and other sectors, Table 5 shows that most of the individual CRI components are lower in W&S contracts. They have a lower share of single bidding, and fewer non-open procedures, contracts that lack call for tenders or short submission periods. However, W&S contracts have slightly more contracts with extremely short decision periods and a significantly higher share of contracts awarded to suppliers with political connections[5]. Overall, W&S contracts have higher average CRI scores than non-water related ones, as also shown in Figure 5, which is largely due to the higher prevalence of political connections-related risks.

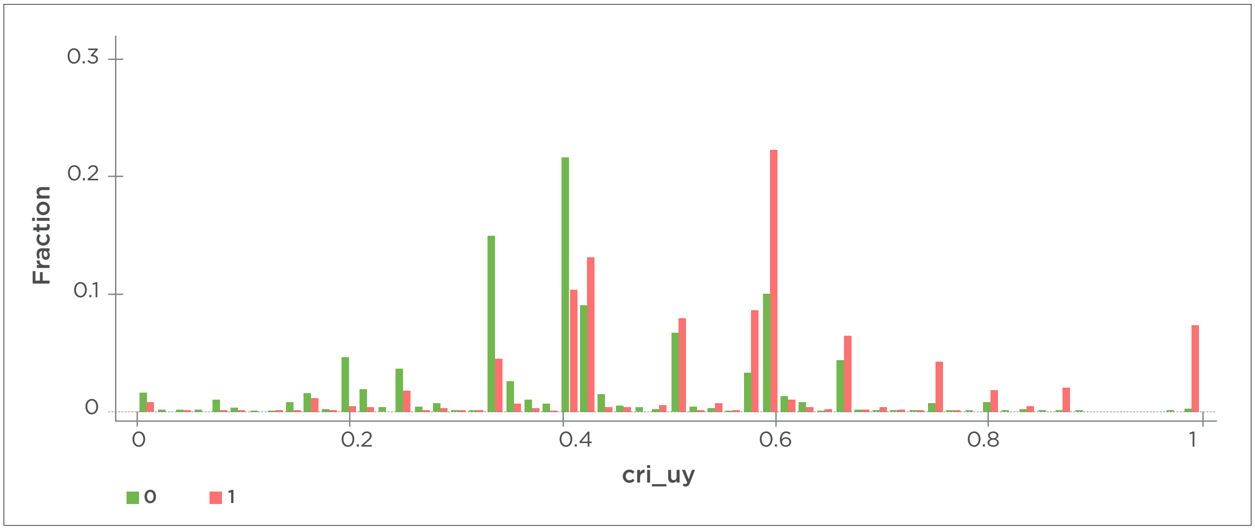
Table 5.
Average of elementary CRI components in Uruguay (2013-2018) ($N_{utilities}$=12,673, N_{other}=644,649)

	Single bidding	Political connection	No call for Tender	Non-open procedure type	Short sub-mission period	Short decision period	Supplier spending share	CRI
W&S sector	9.75%	88.5%	71.3%	77%	57%	63%	4%	0.56
Other sectors	24.7%	5.3%	81%	80.4%	63%	60%	2.5%	0.41

Source: Authors' compilation

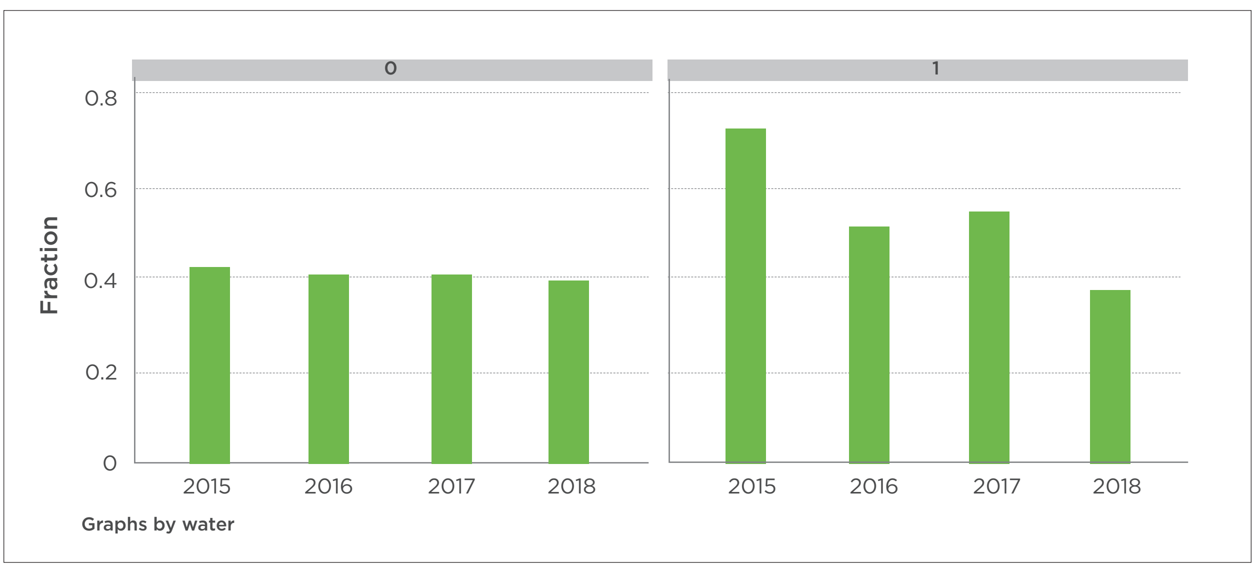
5 Please note that the contracts of Obras Sanitarias del Estado represent a large portion of contracts associated with political connections, influencing this red flag to a considerable degree.

Figure 5: Distribution of contracts by CRI values of water sector (1) and all other sectors (0), (Uruguay, 2013-2018)



CRI values are decreasing over time (see Figure 6). However, it is important to note that there was no complete data for 2018; hence, the average CRI value might falsely signal a risk decrease here.

Figure 6: Distribution of CRI values by water sector (1) and all other sectors (0) (Uruguay, 2015-2018)



Note: 2018 is an incomplete year.

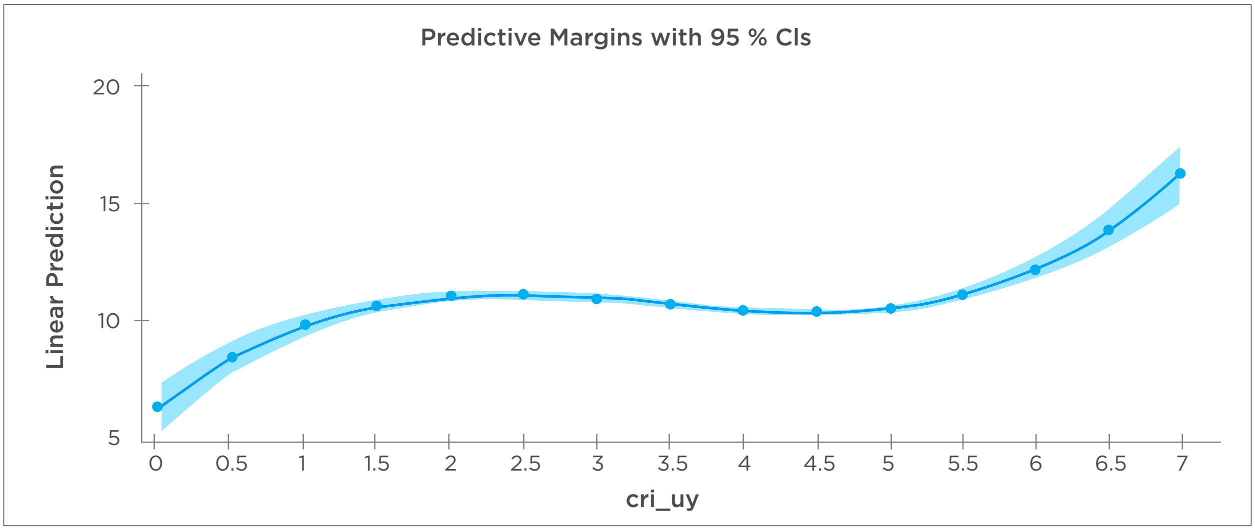
Main results

This section spells out unit price models and potential cost savings. As it was explained in the data description section, there was data on 12,673 contract awards related to the W&S sector. Of these, only 4,453 contracts have all the relevant variables for full regression analysis of the CRI and unit price relationship, considering only contracts for standardized goods.

Simple OLS regression models were built to explain unit prices with the CRI while controlling for product code, buyer type and year. The CRI was entered in the regressions in different versions in order to check for any likely non-linear relationships and interactions with market. In general, it is expected that across most of the sample, more red flags (higher CRI) are associated with higher unit prices. We selected that particular formulation of the explanatory model and hence the shape of non-linear functions, which offered the best regression fit (i.e. highest R^2).

In our preferred specification (Model 3 in Table A1), the relationship between CRI and unit prices is not linear, as shown in Figure 7. Between 0-2.5 red flags, there is a somewhat stronger increase in predicted unit prices; then, the relationship is largely flat for the 2-5 red flags range. For contracts with many red flags, 5 or above, a steeper increase in predicted unit prices is again observed; however, the prediction accuracy decreases predominantly due to a considerably smaller sample size for this high-risk domain. As a simple measure of effect size, in the categorical model (model 5 in Appendix A), going from an average of 4-5 red flags to 5-6 goes together with an approximate 100% estimated increase in unit prices. The identified nonlinear impact curve suggests that a policy strategy aiming to reduce corruption with the greatest cost impact should focus on the highest risk contracts. In other words, the payoffs are greatest to targeting high corruption risk contracts of more than 4.5 red flags. See Appendix A for full regression tables with various alternative specifications.

Figure 7:
Predicted unit price by CRI for W&S related contracts, Model 3 (Uruguay, 2013-2018)[6]



Potential cost savings

The preferred, non-linear regression model can be used to produce savings estimates as a function of corruption risks. Non-linear relationships do not lend themselves to a single price effect coefficient; rather, price effects vary depending on the location on the corruption risk distribution. Nevertheless, it is possible to conceive a sector-wide reform that would lower CRI across all contracts, thereby impacting the whole price distribution. For this reason, two scenarios were examined, conservative and aggressive, stipulating different degrees of average CRI decrease and calculating the average effect of the reforms. In addition to defining the corruption risk reduction scenarios and combining them with regression predictions, the total value of contracts was looked at in order to attach a total price tag to the corruption risk improvement (Table 6).

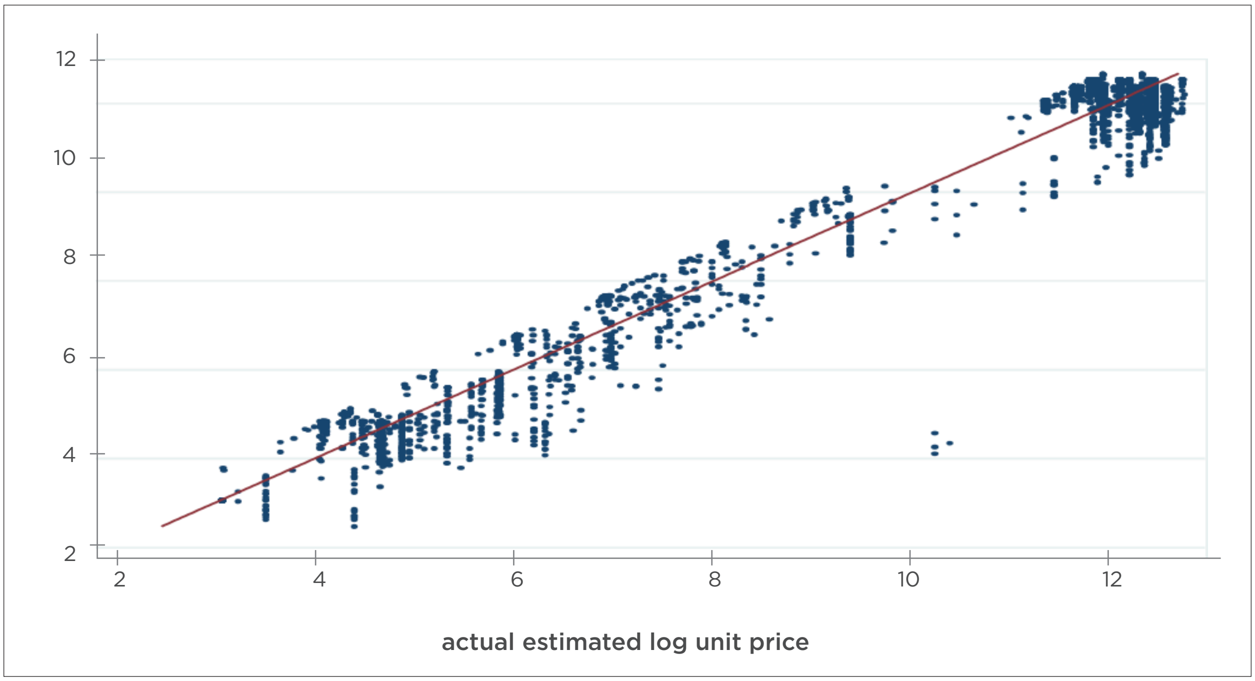
The two savings scenarios deliver starkly different savings, which is largely due to the non-linear relationship between corruption risks and unit prices. The conservative scenario is estimated to lower unit prices by 1.3% on average, albeit with considerable variance around the mean. Figure 8 demonstrates this scenario on the micro-level. It shows how unit prices would change if CRI is reduced on average by 33%, or 1.95 red flags (with random variation around the mean), while holding all other contract characteristics constant. The aggressive scenario, based on a substantial CRI reduction of close to 60%, is estimated to lower unit prices by 16.4%, which translates into 22 million USD spending saved over the 2015-2018 period.

6 1 unit in the x-axis can be interpreted as one additional red flag – as the CRI is built from seven components.

Table 6: Potential savings calculation for water sector contracts (Uruguay, 2015-2018)

Savings scenario	CRI change (number of red flags)	Total spending change (million USD)	Average unit price change (%)
Conservative scenario (~40% CRI decrease)	3.69 -> 2.06	134 -> 132	-1.3%
Aggressive scenario (~60% CRI decrease)	3.69 -> 1.71	134 -> 112	-16.4%

Figure 8: Actual and hypothetical estimated log unit prices, conservative scenario (Uruguay, 2015-2018)



5.2 Mexico

Data description

In Mexico, the federal agency, National Water Commission (Conagua) monitors and ensures financial viability of regional and municipal water and sanitation service providers. Water operating organizations provide access to an improved water source to 96% and improved sanitation services to 88% of the population (Conagua; Bertoméu-Sánchez & Serebrisky, 2018).

In Mexico, readily downloadable, annual databases in CSV format are available in the main national e-procurement system, called CompraNet. The principal dataset, "Contratos," compiles information on tendering and contract details of winning contracts, containing observations on 1.4 million uniquely identifiable public procurement contracts (assigned to 1.2 million unique tenders). The Mexican public authorities, Secretaría de la Función Pública (SFP) and Secretaría de Hacienda y Crédito Público (SHCP) have handled most of the published data in CompraNet on federal procurements since 2010, primarily including public purchases of federal (87.9%) and state (8.14%) government bodies and, to a lesser extent (3.93%), municipalities. Although data was available for the period 2010-2018 (September), data points from 2010 and 2011 were excluded because they had significantly fewer contracts than the later years, probably reflecting the initial incompleteness of the data system. Thus, these early contracts would have biased the results. The dataset includes many relevant variables for calculating corruption risk indicators (red flags), such as contract value amount, buyer and supplier identification and names, contract dates, tender dates, procurement method, award decision date and procurement categories.

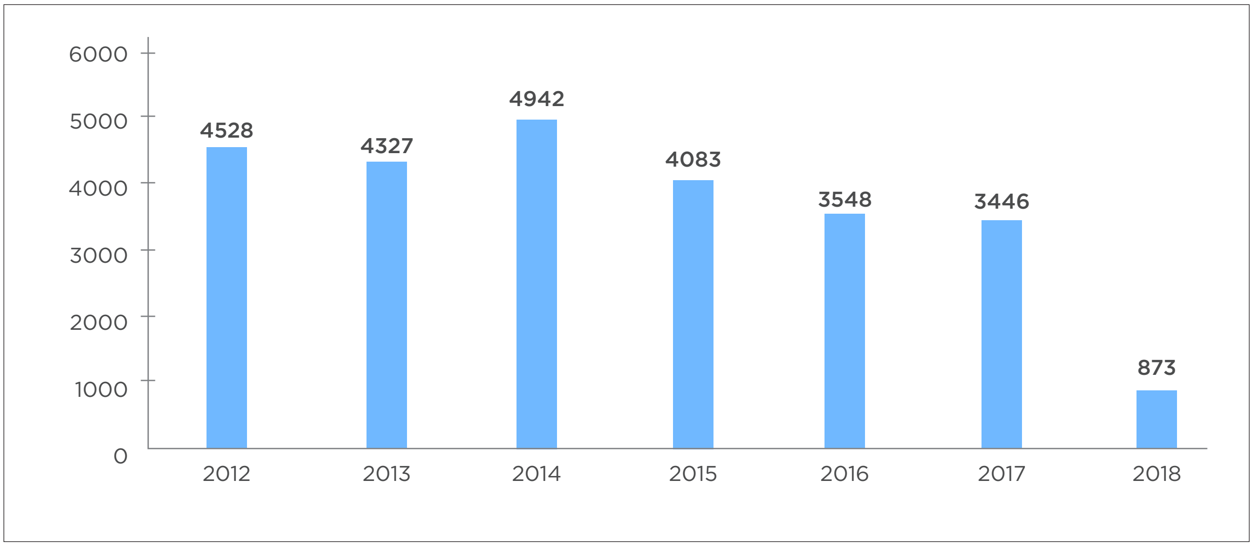
A separate CompraNet data file ('Participantes CompraNetIM') compiled by the Mexican Institute for Competition (IMCO) includes details on winning and losing bidders and their proposals, and covers the period between 2010 and 2017. Variables from this database were added to the CompraNet-Contratos core database by tender ID and supplier name, such as bidder name, buyer name, tender, award and tender status, purchased item quantity, total contract value, procedure form, item classification, and unit prices (which are crucial for measuring the impact of corruption risk on procurement prices). There were around 187,000 unique tenders that could not be matched to the core CompraNet data file. Ninety percent of these were losing and/or unawarded, cancelled tenders, which explains the discrepancy as CompraNet-Contratos contained only successfully awarded contracts.

On the basis of this combined national dataset, the contracts related to the W&S sector were marked in two ways. First, the list of names of Mexican W&S utility companies provided by IBNet was used and the matching buyer names were marked in the procurement dataset. In addition, we searched the buyer names for a number of keywords related to W&S with which to complete the list of relevant buyers, for example, local utilities that were not included in the IBNet list. The keywords tried to capture the different dimensions of the W&S sector, such as drainage, sewerage and water systems. To find the most relevant utilities and products, buyer names and product descriptions were harmonized (accents and whitespaces were removed, and text was converted into lower case). The keywords used include: *"agua", "alcantarillado", "sistema de aguas", "nacional del agua", "conagua", "de cuenca aguas", "aguas y saneamiento", "gestion de cuencas", "aguas del municipio".*

Secondly, a range of keywords were used to search product descriptions in the procurement dataset in order to mark those contracts that are also related to the W&S sector. The keywords used include: *"servicios de agua", "sistema" and "agua", "cuenca" and "agua", "alcantarillado" and "agua, "saneamiento" and "agua", "drenaje and "agua".*

The number of contracts marked according to these two methods amounted to 30,884, including all contracts specifically related to W&S products based on their tender title (around 4,000 contracts) and all contracts of W&S utility companies (around 27,000 contracts) – see the distribution by year in Figure 9, below. The majority of contracts, around 21,000, were done by the National Water Commission (Comisión Nacional del Agua), while departmental utilities had lower numbers of contracts.

Figure 9: Number of contracts related to the W&S sector (Mexico, 2012-2018)



Note: 2018 is incomplete year.

The dataset for W&S-related contracts contained many of the key variables; however, a few crucial ones had high missing rates, such as unit price and product code. Tenders with missing values on key variables of the analysis were excluded from the regression analysis. See Figure 10, below, for an overview of missing rates for key variables.

Figure 10: Share of non-missing data for W&S sector-related contracts (Mexico, 2012-2018)

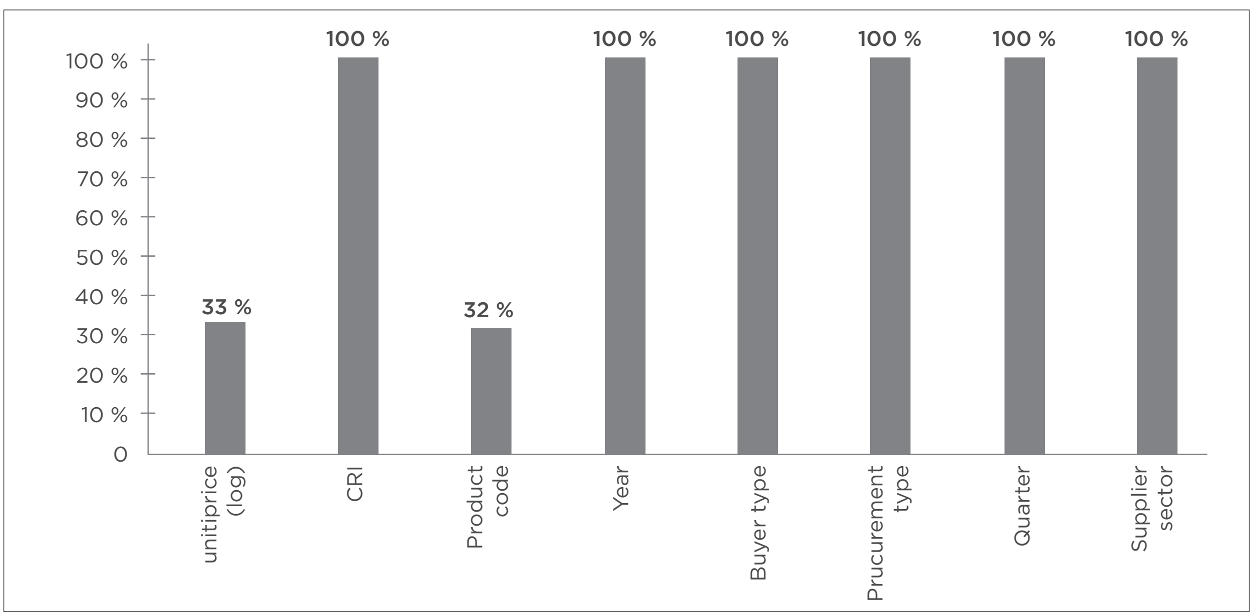
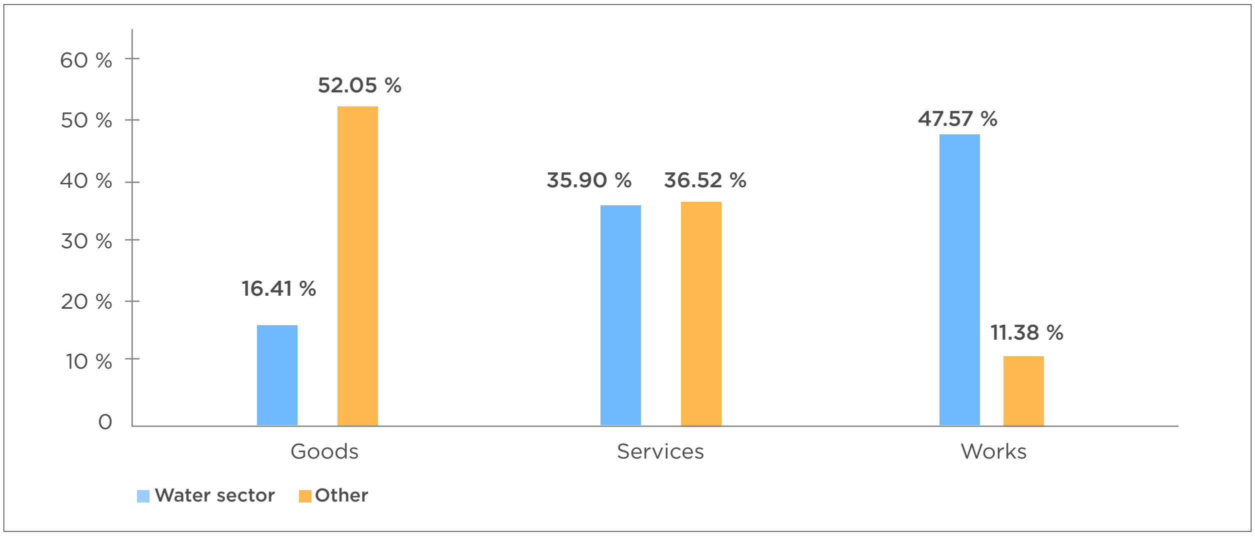


Figure 11 shows that most W&S-related contracts go to public works purchases (47.32%). The second biggest sector by contract number is services (35.9%), and only a small part is for goods (16.41%). These shares differ significantly from the average spending structure in the other sectors: the share of public works spending is roughly four times higher, while goods purchases are three times smaller.

Figure 11: Distribution of awarded contracts in water sector vs. all other sectors (Mexico, 2012-2018)



Note: CompraNET contained procurement category information

Corruption Risk Index

A number of corruption risk indicators (red flags) could be calculated and validity tested for the Mexican dataset, where 0 stands for non-risky behavior, 0.5 indicates a medium-risk situation (where applicable), and 1 signifies a high corruption risk. In total, 11 valid risk indicators were identified (overview in Table 7), with eight of them related to the tendering process, and three based on information on supplier risks.

The three supplier risk indicators measure whether a company is registered in a country considered a tax haven according to the Financial Secrecy Index, whether a company has been listed as sanctioned on the Mexican government's directory of sanctioned suppliers and contractors[7], and a supplier's share in a buyer's total spending in a year.

7 https://directoriosancionados.funcionpublica.gob.mx/SanFicTec/jsp/Ficha_Tecnica/SancionadosN.htm

The eight tendering risk indicators are related to different aspects of the procurement process. First, all the different procedure types used in Mexico were classified into open and non-open procedure types based on their association with single bidding (See Appendix G for regression details). Please note that we identify red flags (e.g. classify procedure types as non-open) based on their association with non-competitive outcomes, such as single bidding in regression analysis. Consequently, the following national procedure types are considered "open": *Licitación Pública Estatal, Licitación Pública, Licitación Pública con OSD.* These national procedure types are considered non-open*: Adjudicación Directa Federal, Adjudicación Directa, Invitación a Cuando Menos 3 Personas, Otro, and Proyecto de Convocatoria.* Second, not publishing the call for tenders was considered a red flag, and third, if the number of accompanying documents published was less than two, a red flag was also raised.

Fourth, the length of the period available for bid submission and the length of the period of time for the procuring body to make an award decision were measured. In the case of Mexico, submission periods of fewer than 15 days are associated with a high risk of corruption. For decision periods, those that are shorter than nine days raise a red flag. In both cases, the exact thresholds were defined so that the risk categories predict single bidding probability the best, because we expect high-risk features of the procurement process leading to restricted competition (single bidding) (See Appendix G for regression details). Fifth, a red flag was raised when there was only one bid submitted for a tender (single bidder). Lastly, contract modification carried out during the tendering phase or during contract delivery was also considered a red flag.

Table 7. Red flag definitions, Mexico

Indicator group	Indicator name	Indicator definition
Tendering risk	Procedure type	0 = open, competitive procedure 1 = non-open procedure (e.g. direct contracting)
Tendering risk	Lack of call for tender publication	0 = call for tenders published 1 = call for tenders not published
Tendering risk	Number of documents published	0 = documents published >=2 1 = documents published <2
Tendering risk	Length of submission period	0 = submission period >=15 days 1 = submission period <15 days
Tendering risk	Length of decision period	0 = decision period >=9 days 1 = decision period <9 days
Tendering risk	Single bidder contract	0 = more than one bid received 1 = one bid received
Tendering risk	Contract modification during advertisement	0 = contract not modified during advertisement 1 = contract modified during advertisement
Tendering risk	Contract modification during implementation	0 = contract not modified during delivery 1 = contract modified during delivery
Supplier risk	Supplier company registered in tax haven	0 = company not registered in tax haven 1 = company registered in tax haven
Supplier risk	Sanctioned companies	0 = company not listed as sanctioned 1 = company listed as sanctioned
Supplier risk	Supplier spending share	The supplier's share in a buyer's total spending in a year

Having tested these 11 indicators for their validity, the composite Corruption Risk Index (CRI) was built as the simple arithmetic average of the individual risk indicators, falling between 0 and 1, with 1 representing the highest observed corruption risk and 0 the lowest. Among other things, the CRI indicator developed here allows for scoring each contract award and identifying those with the highest risk. Figure 12 shows the approximately normal distribution of risks among contract awards. In simple terms, a contract with the average CRI score has around four red flags out of the 11 measured red flags present. The majority (~60%) of contracts are below the average red flag score (~4 red flags), while 15% of the contracts have around five to six red flags identified. There are no contracts where all 11 valid indicators are present, the maximum number of red flags present in a contract is eight.

Figure 12. CRI distribution of contracts Mexico, 2012-2018.

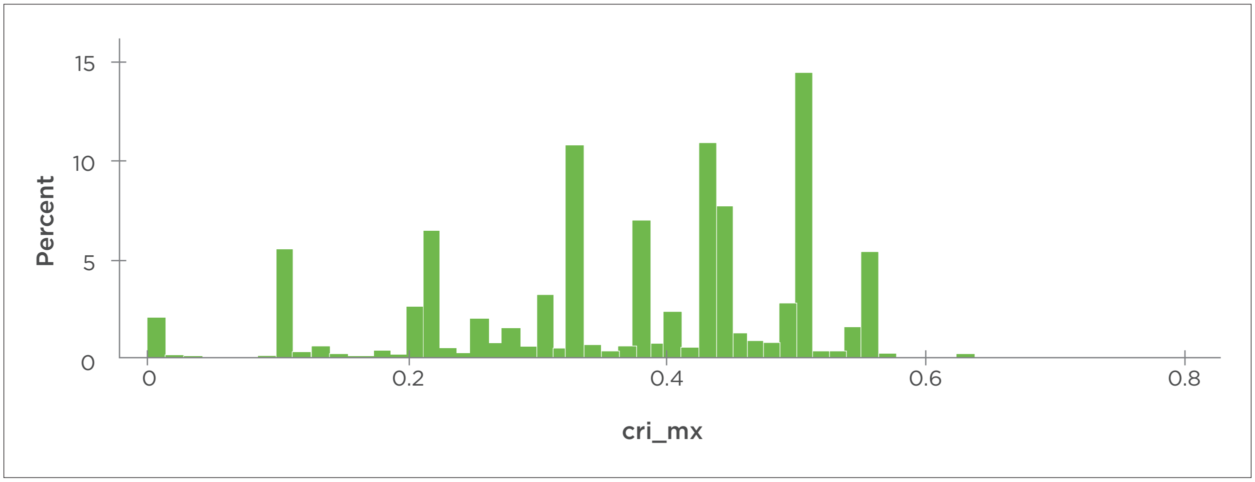


Table 8 shows the elementary CRI components' and CRI's average for W&S sector and other sectors' contracts. It shows that almost all elementary risk factors are lower in W&S sector contracts. For example, they tend to publish call for tenders and they have lower shares of non-open procedures, extremely short submission and decision periods. However, they have a ~2 percentage points higher share of single bidder contracts. These differences can be partly explained by the fact that W&S sector contracts have a different spending structure. For example, the average contract size is twice as big for W&S contracts as for the whole sample.

Table 8: Average of elementary CRI components in Mexico (2012-2018) Nw&s= 25,747, Nother=1,563,274)

	Single bidding	No call for Tender	Non-open procedure type	Short submission period	Short decision period	Supplier spending share	Tax haven	Documents	Modifications before	Modifications after	Sanctions	CRI
W&S sector	19.8%	33.6%	86.5%	44.1%	41.3%	23.1%	0.0%	52.6%	2.6%	0.0%	0.3%	0.29
Other sectors	17.9%	55.6%	87.5%	71.6%	65.7%	42.5%	0.1%	75.3%	2.1%	0.1%	0.7%	0.37

Figure 13 and Figure 14 show the difference between W&S contracts and all other contracts in CRI distribution. Low CRI values are more frequent for utility contracts – see the red spikes on the left-hand side of the figure.

Figure 13: Distribution of contracts by CRI values of the W&S sector (1) and all other sectors (0) (Mexico, 2012-2018)

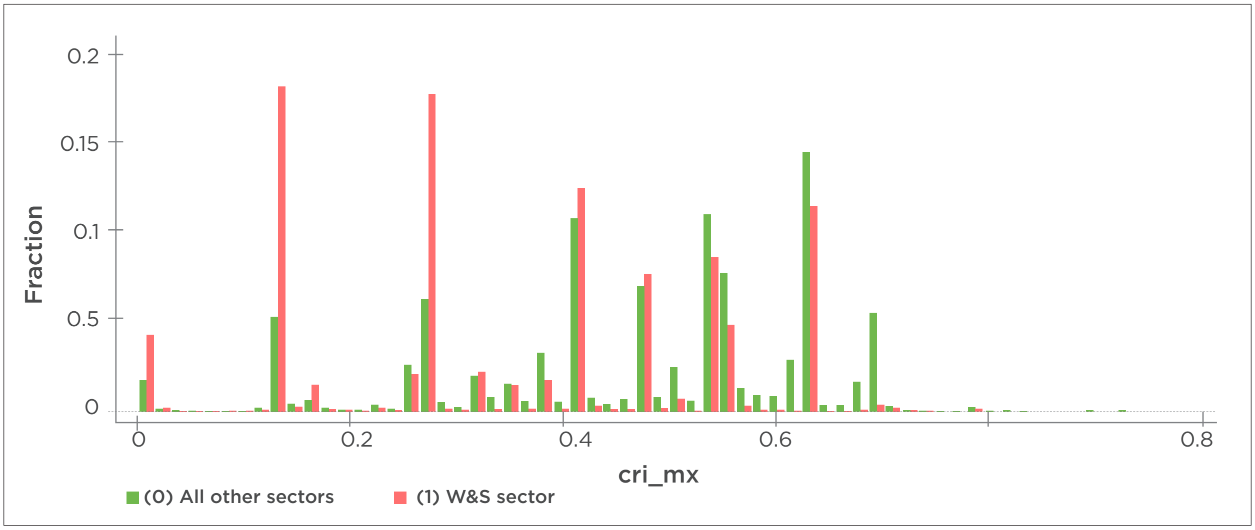
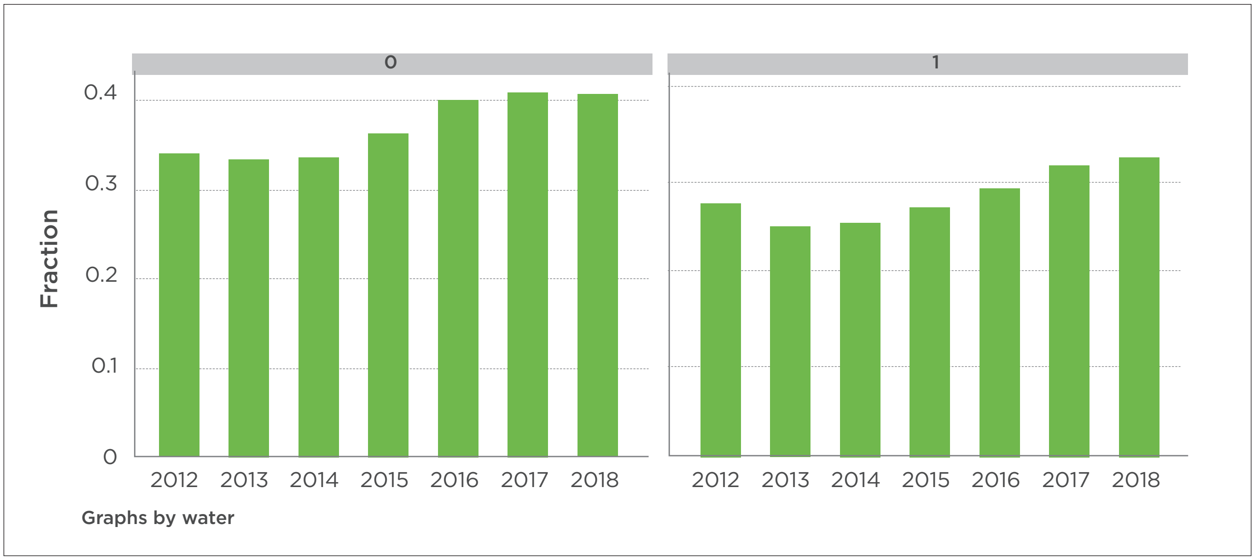


Figure 14: Distribution of CRI values in the W&S sector (1) and all other sectors(0) (Mexico, 2012-2018)



Note: 2018 is an incomplete year

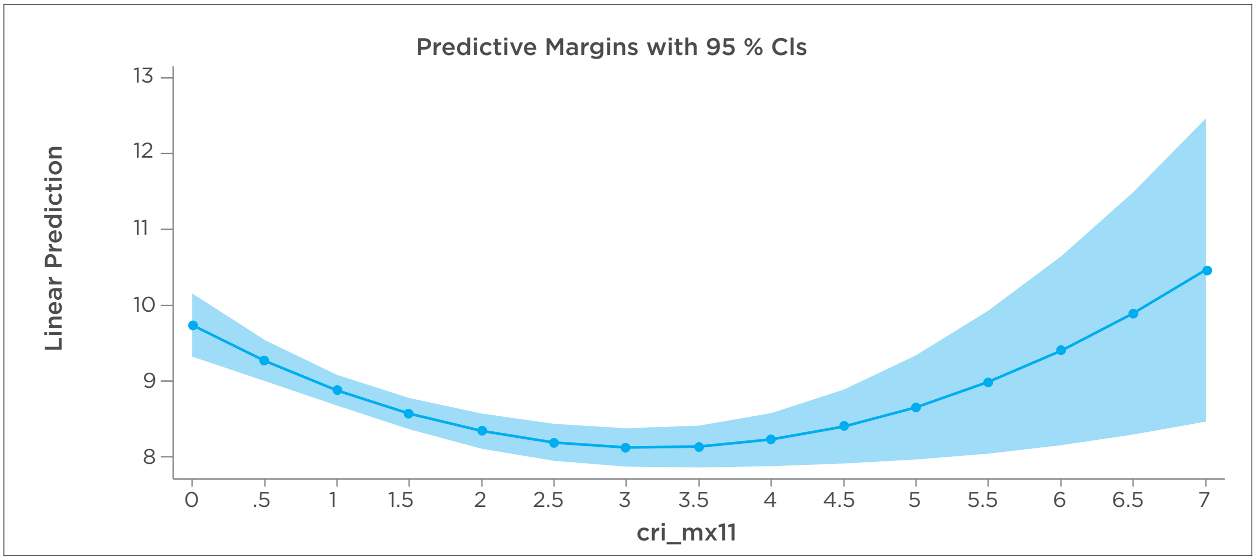
Main results

This section spells out unit price regression models and potential cost savings. As it was explained in the data description section, there was data on 30,884 contract awards related to the W&S sector. Out of these, only 1,402 contracts have all the relevant variables for full regression analysis of the CRI and unit price relationship, considering only contracts for standardized goods. Such a drastic drop in sample size was due to two main factors. First, we have relatively few contracts on goods purchases – where unit prices are meaningful – that are W&S sector-related in the dataset. Second, key variables such as unit prices are missing for a large share of contracts.

Simple OLS regression models were built explaining unit prices with the CRI while controlling for product code, buyer type, winner's legal form, winner's sector and year. The CRI was entered in the regressions in different versions in order to check for any likely non-linear relationships and interactions with market. In general, it is expected that across most of the sample, more red flags (higher CRI) are associated with higher unit prices. We selected that particular formulation of the explanatory model and hence the shape of non-linear functions that offered the best regression fit (i.e. highest R^2).

In our preferred specification (R^2=0.83), the relationship between CRI and unit prices is non-linear as shown in Figure 15. We find a surprising downward sloping relationship at the lower end of the CRI distribution (0-3 red flags), which may be due to lack of data as 90% of the contracts have between two to five and a half red flags. For the bulk of the CRI distribution (three red flags and more) we find an upward sloping relationship between corruption risk and unit prices. As a simple measure of effect size, in the quadratic model (Model 2 in Table B1), an additional red flag compared to the average red flag score (three red flags) is associated with an 11% increase in unit prices. The identified non-linear impact curve suggests that a policy strategy aiming to reduce corruption with the greatest cost impact should focus on the highest risk contracts. In other words, the payoffs are greatest to targeting mid- to high-corruption risk contracts of more than three red flags. See Appendix B for full regression tables with various alternative specifications.

Figure 15: Predicted unit price (in logarithm) by CRI values (Model 2) (Mexico, 2012-2018)



Potential cost savings

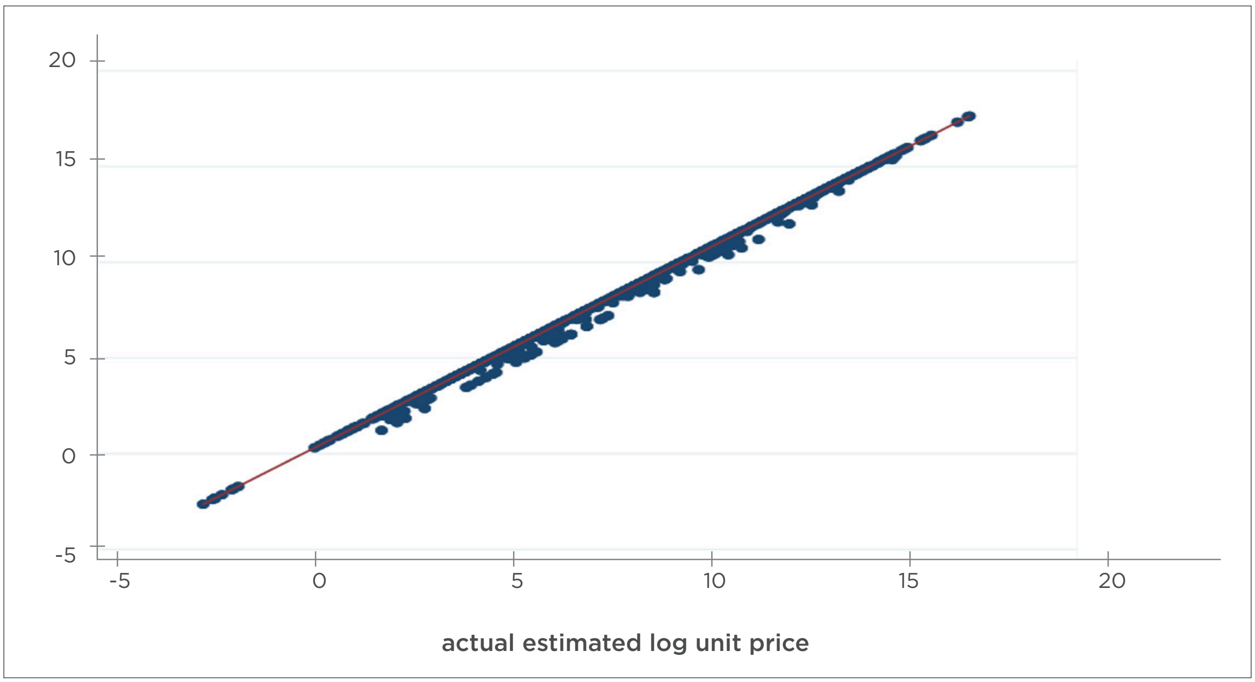
The preferred, non-linear regression model can be used to produce savings estimates as a function of corruption risks. Non-linear relationships do not lend themselves to a single price effect coefficient; rather, price effects vary depending on the location on the corruption risk distribution. Nevertheless, it is possible to conceive a sector-wide reform that would lower CRI across all contracts, thus impacting the whole price distribution. Hence, two scenarios were looked at, conservative and aggressive, stipulating different degrees of average CRI decrease and calculating the average effect of the reforms. In addition to defining the corruption risk reduction scenarios and combining them with regression predictions, we also look at the total value of contracts in order to attach a total price tag to the corruption risk improvement (Table 9).

The two savings scenarios deliver similarly small savings estimates, which is due to the overall weak relationship between unit prices and corruption risks and the linear relationship for most of the CRI distribution (Table 9). The conservative scenario is estimated to lower unit prices by 0.8% on average, with little variance around the mean. The aggressive scenario, based on a substantial CRI reduction of 66%, is estimated to lower unit prices only by 1.1% which translates into a 3 million USD spending saved over the 2012-2018 period. Figure 16 shows the log unit price savings on the contract level under the aggressive scenario. It shows how unit prices would change if CRI is reduced on average by 66% or 2.07 red flags (with random variation around the mean) while holding all other contract characteristics constant.

Table 9: Potential savings calculation for W&S sector contracts (Mexico, 2012-2018)

Savings scenario	CRI change (number of red flags)	Total spending change (million USD)	Average unit price change (%)
Conservative scenario (33% CRI decrease)	3.14 -> 2.11	171 -> 170	-0.8%
Aggressive scenario (66% CRI decrease)	3.14 -> 1.07	171 -> 169	-1.1%

Figure 16: Actual and hypothetical estimated log unit prices, aggressive scenario (Mexico, 2012-2018)



Colombia

Data description

Colombia

Provision of W&S services in Colombia is the responsibility of municipal public companies, ensuring access to water services and sanitation to around 96% and 85% of the population, respectively (Bertoméu-Sánchez & Serebrisky, 2018).

The public procurement dataset for Colombia was compiled from a combination of three data sources: the datasets downloadable from the national procurement portals SECOP I and SECOP II, as well as the separate publication in the Open Contracting Data Standard (OCDS). The overlap between the OCDS and SECOP I datasets was almost complete (99.9%). As SECOP I data was ready to download in a single CSV file, while OCDS releases would have to be transformed, the decision was made to take SECOP I data as the core of the dataset. Then, SECOP I and II were combined into the final dataset whenever SECOP II data was also available. The calculation of corruption risk indicators was performed on this combined dataset covering the 2015 -2018 period.

SECOP I included most of the variables relevant for indicator calculation, covering a longer period (2011-2018) than SECOP II (2015-2018), which was launched in 2015. State entities are obliged to publish their public contracting activities in SECOP I or II, ensuring procuring bodies' accountability; therefore, data focus on contract details (buyer, supplier information, purchased items, contract duration, contract value, procurement method), including purchases of both centralized and decentralized government bodies at national, regional and local levels. SECOP II is a transactional platform, where governmental bodies and potential suppliers can register and complete procurement processes online, publishing real-time data on the ongoing procurements, sharing information on all contracting phases, especially on award and tender phase and payments.

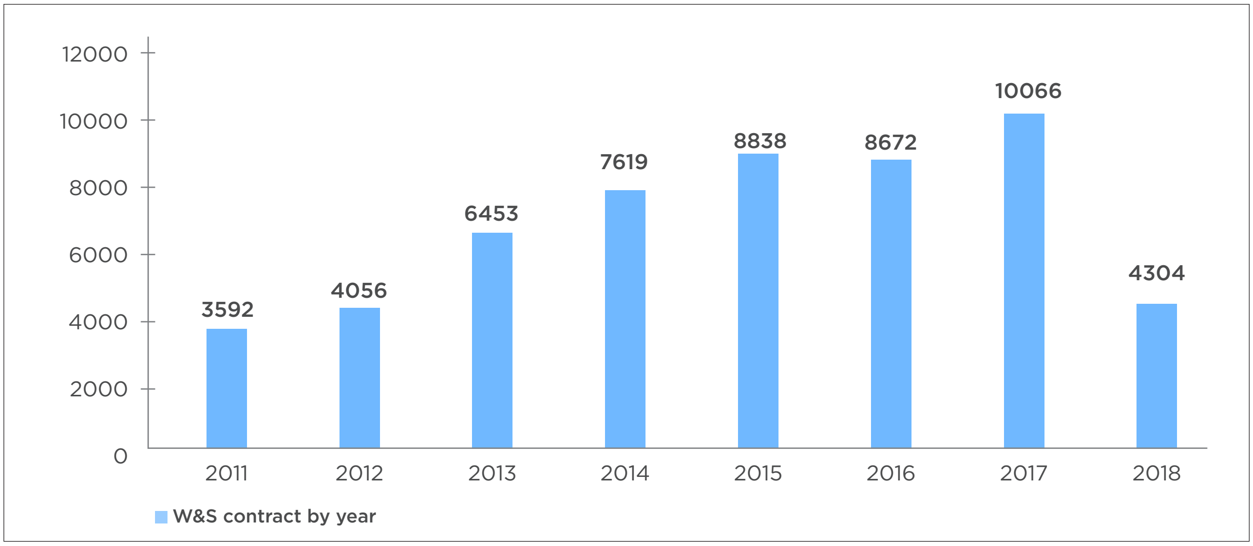
The combined dataset contained 2.3 million observations with high-quality data available on contract details such as value amount, dates, suppliers and buyer identification, tender procurement method, tenders and awards. Missing rates ranged from 0% to 18% for different variables. Data related to tender (dates, number of tenderers) and award status were not included in SECOP I, only in SECOP II. None of the data sources included explicit information on contract amendments.

On the basis of this combined national dataset, the contracts related to the W&S sector were marked in two ways. First, the list of names of Colombian W&S utility companies provided by IBNet was used and the matching buyer names were marked in the procurement dataset. In addition, a number of keywords related to the W&S sector were searched in buyer names in order to complement the list of relevant buyers, e.g. local utilities that were not included in the IBNet list. The keywords tried to capture the different dimensions of the W&S sector, such as drainage, sewerage, and water systems. To find the most relevant utilities and products, buyer names and product descriptions were harmonized (accents and whitespaces were removed and text was converted into lower case). The selected utilities and their official website were reviewed. As part of the regional association Acuavalle S.A. ESP, the main provider of drinking water and sanitation in the region of Valle del Cauca, the corresponding department was also selected. The keywords used for the Colombian context include: *"aguas de", "vallecaucana", "valle del cauca - empresas publicas municipales de cartago", "aguazul espa s.a. e.s.p.", "aguas y aseo", "saneamiento basico", "emcoaguas", "aguas" and "s.a. e.s.p.", "aguas claras", "de agua", "acueducto", "alcantarillado", "sanitaria", "de aseo", "acuasan".*

Second, a range of keywords were used to search product descriptions in the procurement dataset in order to mark those contracts that are also related to the W&S sector. The keywords used include: *"acueducto" and "agua", "saneamiento" and "conexiones", "sistema de agua", "saneamiento", "cuenca" and "agua", alcatarillado" and "drenaje", "fontaneria" and "agua", "sistemas de abastecimiento" and "agua", "pozos" and "agua", "canal" and "agua", "constr" and "agua".*

The number of contracts marked according to these two methods amounted to 72,234, including all contracts specifically related to W&S products based on their tender title (around 50,000 contracts) and all contracts of W&S utility companies (around 22,000 contracts) (see Figure 17, below). Of all the utilities, the majority of contracts (over 4,000) were done by the public utility Empresa de Acueducto y Alcantarillado de Bogotá - E.S.P., while other companies had mostly fewer than 100 contracts related to the W&S sector.

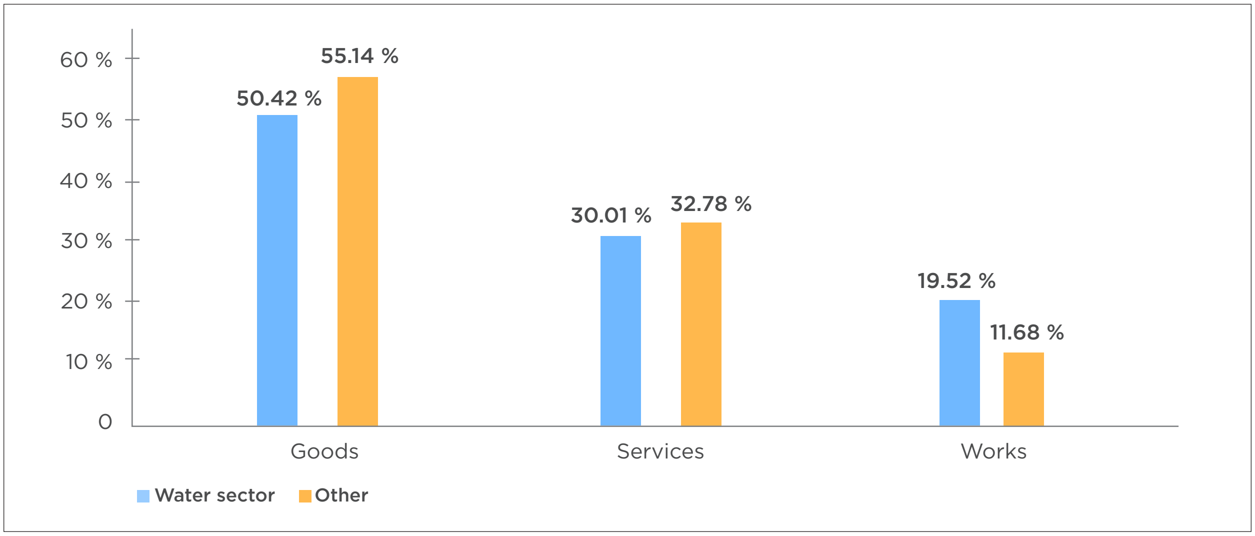
Figure 17: **Number of W&S sector contracts (Colombia, 2011-2018)**



Note: 2018 is an incomplete year

Most of the water sector-related contracts are for goods (50.42%) and services (30.01%). Contracts for public works cover one-fifth of total spending in the W&S sector, while it takes up roughly 12% in other sectors, as shown in Figure 18.

Figure 18: Distribution of awarded contracts in the W&S sector vs. all other sectors (Colombia, 2011-2018)



Note: SECOP data included procurement category information

Corruption Risk Index

A number of corruption risk indicators (red flags) could be calculated and validity tested for the Colombian dataset, where 0 stands for non-risky behavior, 0.5 indicates a medium-risk situation (where applicable), and 1 signifies a corruption risk. In total, nine valid risk indicators were identified (overview in Table 10), with six of them related to the tendering process and three based on information on supplier company risks. The supplier risks include whether a company is registered in a country considered a tax haven according to the Financial Secrecy Index, whether a supplier is registered in the same province as a buyer, and the supplier's share in a buyer's total spending in a year.

The six tendering risks are related to different aspects of the procurement process. First, all the different procedure types used in Colombia were classified into open and non-open procedure types based on their association with single bidding (See Appendix H for regression details). Please note that we identify red flags (e.g. classify procedure types as non-open) based on their association with non-competitive outcomes such as single bidding in regression analysis. Consequently, the following national procedure types are considered open: *Concurso de méritos abierto, Concurso de méritos con lista corta, Concurso de méritos con lista multiusos, Contratación mínima cuantía, Contratos y convenios con más de dos partes, Enajenación de bienes con subasta, Licitación obra* *pública, Licitación pública, Licitación pública acuerdo marco de precios, Licitación pública obra pública, Lista multiusos, Selección abreviada de menor cuantía, Selección abreviada servicios de salud, Selección abreviada subasta inversa, Selección Abreviada Menor Cuantía Sin Manifestación Interés, solicitud de información a los proveedores, Subasta. On the other hand, these national procedure types are considered non-open: Asociación público privada, Contratación directa, Contratación directa (con ofertas), Contratación Directa (Ley 1150 de 2007), Contratación régimen especial, Contratación régimen especial (con ofertas), Enajenación de bienes con sobre cerrado, Iniciativa Privada sin recursos públicos, Lista multiusos, Mínima cuantía.*

Second, not publishing the call for tenders in the official e-procurement system was considered a red flag. Third, the length of the period given for bid submission and the period of time it takes for the procuring body to announce a decision were measured. In the case of Colombia, submission periods of fewer than six days are associated with a high risk of corruption. For decision periods, those shorter than 14 days raise a red flag. In both cases, exact thresholds were defined so that risk categories predict single bidding probability the best, because we expect high-risk features of the procurement process leading to restricted competition (single bidding) (See Appendix H for regression details). Fourth, a red flag was raised when there was only one bid submitted for a tender (single bidder). Lastly, a red flag was raised when a contract has a relative delay (percentage of days overrun compared to the estimated project length) of more than 75%. The cut-point was defined by regression analysis (Appendix H).

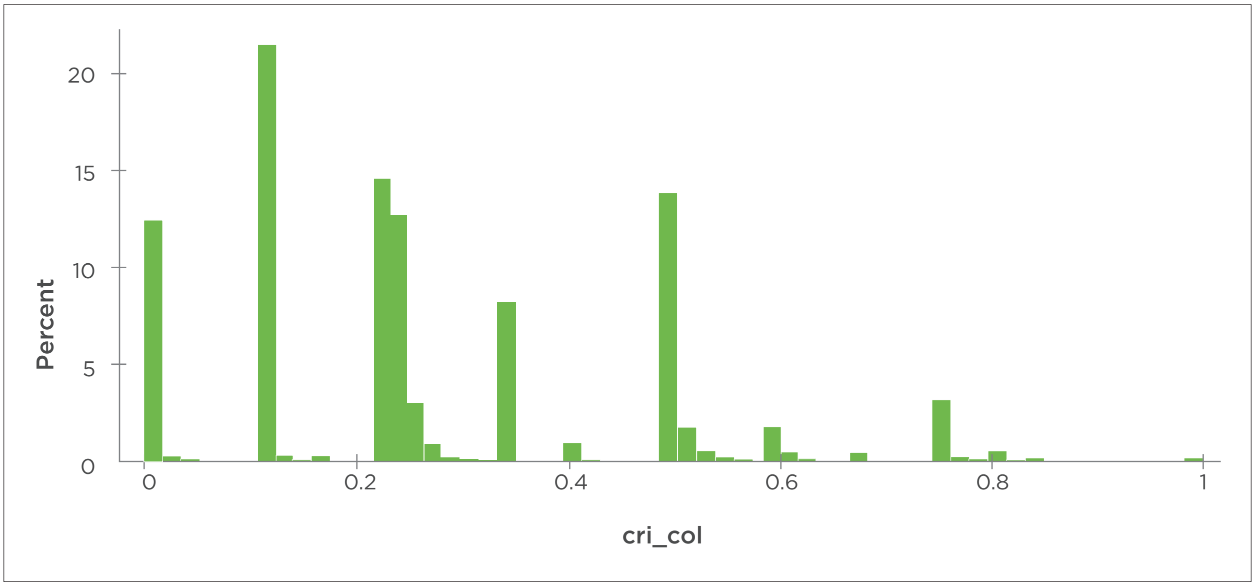
Table 10. Red flag definitions, Colombia

Indicator group	Indicator name	Indicator definition
Tendering risk	Procedure type	0 = open, competitive procedure 1 = non-open procedure (e.g. direct contracting)
Tendering risk	Lack of call for tender publication	0 = call for tenders published 1 = call for tenders not published
Tendering risk	Length of submission period	0 = submission period >=6 days 1 = submission period <6 days
Tendering risk	Length of decision period	0 = decision period >=14 days 1 = decision period <14 days
Tendering risk	Single bidder contract	0 = more than one bid received 1 = one bid received
Tendering risk	Relative delay of project duration*	0 = 0-75% longer than estimated 1 = over 75% longer than estimated
Supplier risk	Supplier company registered in tax haven	0 = company not registered in tax haven 1 = company registered in tax haven
Supplier risk	Same location of buyer and supplier	0 = company not registered in same province as buyer 1 = company registered in same province as buyer
Supplier risk	Supplier spending share	The supplier's share in a buyer's total spending in a year

* this component is excluded from the analysis explaining delays

Having tested these nine indicators for their validity, the composite Corruption Risk Index (CRI) was built as the simple arithmetic average of the individual risk indicators, falling between 0 and 1, with 1 representing the highest observed corruption risk and 0 the lowest. Among other things, the CRI indicator developed here allows for scoring each contract award and identifying those with the highest risk. Figure 19 shows a rather staggered distribution of risks among contract awards potentially suggesting typical combinations of red flags. In simple terms, a contract with the average CRI score displays around two to three red flags out of the nine measured red flags. Two-third of the contracts have lower than the average number of red flags, while 25% of all contracts have between four and seven red flags present. There are 2,739 contracts with all valid indicators present.

Figure 19. CRI distribution of contracts Colombia, 2011-2018.

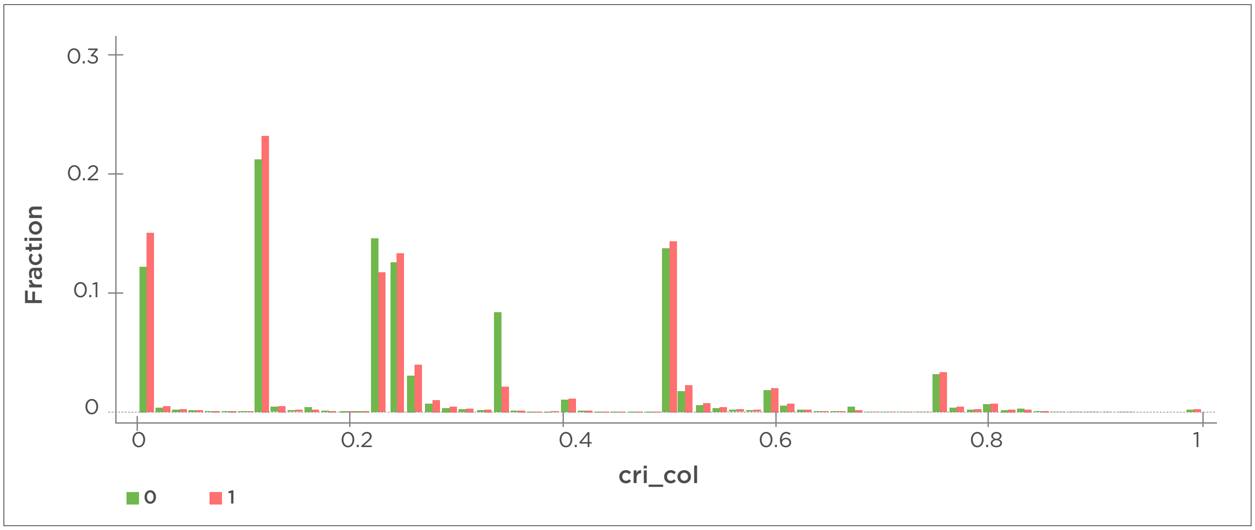


Comparing corruption risks in the W&S sector and other sectors, Table 11 shows that most of the individual CRI components are at a similar level or somewhat lower in W&S contracts. They have a lower share of non-open procedures, contracts that lack call for tenders or relative delays. However, they have a slightly higher share of single bidding, extremely short submission and decision periods, and suppliers registered in a tax haven. Overall, W&S contracts have slightly lower average CRI scores than non-water related ones, as also shown in Figure 20.

Table 11. Average of elementary CRI components in Colombia (2011-2018) ($N_{W\&S}$= 72,234, N_{other}= 2,338,802)

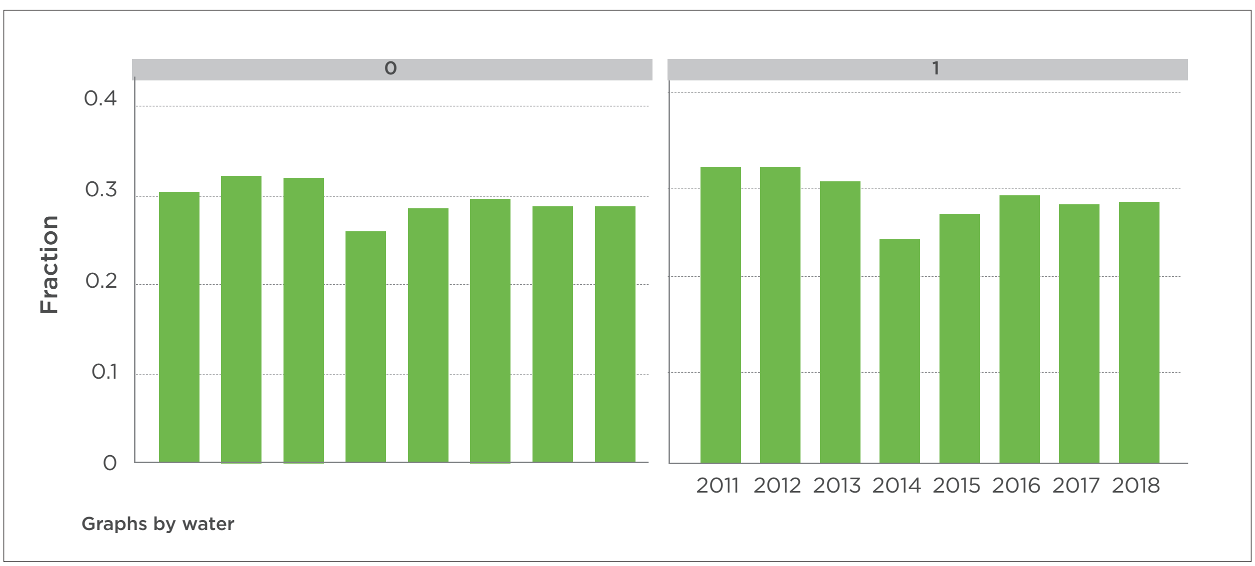
	Single bidding	No call for Tender	Non-open procedure type	Short submission period	Short decision period	Tax haven	Same location	Relative delay	Supplier spending share	CRI
W&S sector	99%	69%	43%	80.4%	79%	24.6%	67.7%	13%	3.9%	0.26
Other sectors	98%	83%	53%	77%	74%	21.5%	67.3%	13.7%	3.3%	0.27

Figure 20: Distribution of contracts by CRI values of W&S sector (1) and all other sectors (0), (Colombia, 2011-2018)



CRI values demonstrate a decreasing tendency over the period of 2011-2014 for W&S contracts, reaching its lowest value at 0.26 in 2014, after which a modest increase and then stagnation follow (See Figure 21). Non-W&S sector contracts follow similar trajectory, except there is an increase from 2011 to 2012.

Figure 21: Distribution of CRI values by W&S sector (1) and all other sectors (0) (Colombia, 2011-2018)



Note: 2018 is an incomplete year

Main results

This section spells out relative delay and cancellation explanatory models. As it was explained in the data description section, there was data on 72,235 contract awards related to the W&S sector. However, due to the fact that on the contract level both delay and cancellation can be corruption risk factors themselves, the analysis is performed on the buyer level. In total, 534 buyers were identified in Colombia for the whole 2011-2018 period, with at least 25 contracts awarded in the W&S sector. These entities were responsible for 34,177 contract awards. Hence, the OLS regression analysis was run for 534 buyers representing 34,177 contracts.

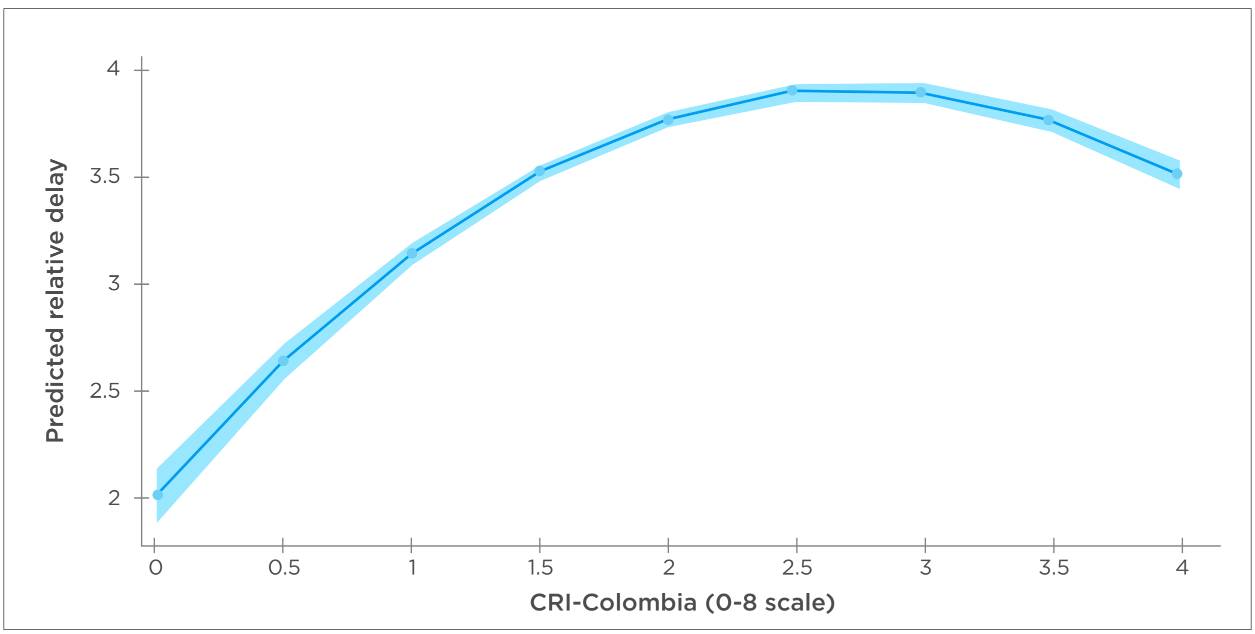
Simple OLS regression models were built explaining two different outcome variables, neither of which relates to prices because price information, either unit prices or relative prices, are not available in the public procurement dataset for Colombia. Instead, the two dependent variables capture different aspects of how corruption risk can affect project delivery: i) relative delay (eventual number of days for contract completion/originally planned number of days for contract completion)[8]; and ii) tender cancellation. These two dependent variables are aggregated at the buyer level so average relative delay and cancellation rate (number of cancelled tenders/number of commenced tenders) are regressed. Each of the regressions on the buyer level includes controls for: buyer type, utility (Y/N) and buyer location. The observations are weighted by the number of contracts awarded to preserve the representativeness of the analysis and take into account the size of each buyer. Corruption is expected to increase both delays and cancellations in line with the theoretical framework.

8 Note that relative delay serves as an outcome variable here and is not to be confused with the relative delay indicator used for the CRI calculation.

Just like for the relative price models, CRI is entered in the regressions in different versions in order to check for any likely non-linear relationships. In addition, its interaction with the utility dummy is also examined.

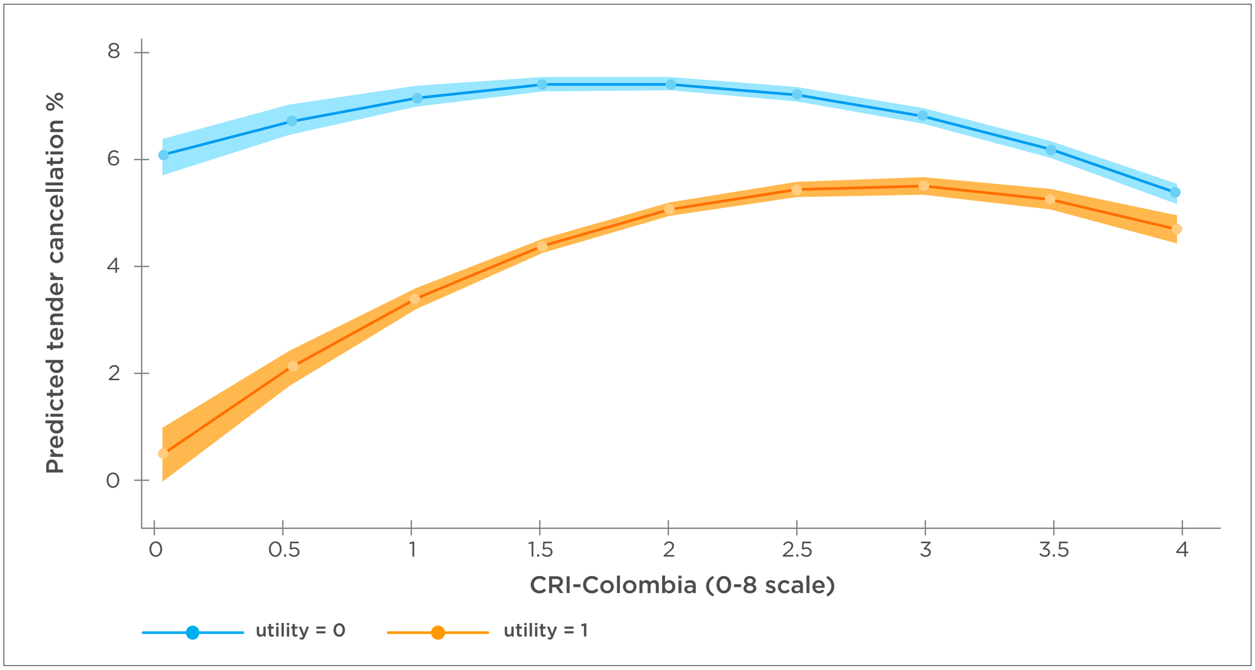
The explanatory power of our preferred regression models (Models 2 and 5 in Table C1) is relatively high, with R^2 falling in the range of 0.3-0.4. In these models, the relationship between CRI and project delivery outcomes (delay and cancellation) is quadratic and particularly steep at the lower end of the CRI distribution. For example, the second order polynomial regression of relative delivery delay on CRI shows a strong increase of delays in the range of 0-2.5 red flags and then the relationship flattens (Figure 22). Similarly, the second order polynomial of CRI, interacted with utility, on cancellation rate shows a steep positive relationship in the 0-3 red flags range, then the relationship flattens out (Figure 23). The identified non-linear impact curve suggests that a policy strategy aiming to reduce corruption with the greatest contract delivery impact should focus on average risk contracts. In other words, the payoffs are greatest to targeting moderate corruption risk contracts of around two to three red flags by lowering their risks to close to a minimum of zero to one red flags. See Appendix C for full regression tables with various alternative specifications.

Figure 22: Predicted relative delay (percent point) by CRI values[9], buyer level (Colombia, 2011-2018) (Model 2)



9 One unit in the x-axis can be interpreted as one additional red flag – as the CRI is built up from eight components for this analysis.

Figure 23: Predicted average tender cancellation percent by CRI values[10], buyer level (Colombia, 2011-2018) (Model 6)



Note: *utility=0 represents the tenders of non-utility buyers and utility=1 of utilities

Potential project delivery improvements

The two preferred, non-linear regression models can be used to produce estimates of reduced project delay and tender cancellation due to lowering corruption risks. Once again, we define sector-wide reforms which lower CRI across all contracts and hence impact on the whole distribution of relative delays as well as tender cancellations. Two scenarios were examined for each outcome -- a conservative and aggressive scenario -- stipulating different degrees of average CRI decrease. The impacts are reported separately for the two dependent variables (Table 12). The predicted changes in the dependent variables are also visually represented in Figure 24 and Figure 25. These show on the micro-level how relative delay and cancellation rates would change if CRI is reduced by 33% on average with random variation around the mean, while holding all other variables constant.

Considering relative delays, the conservative scenario is based on a modest, 0.6 red flag reduction and it leads to a 0.2 percentage point decline in relative delay. A

10 One unit in the x-axis can be interpreted as one additional red flag – as the CRI is built up from nine components for this analysis.

more aggressive scenario, lowering the average CRI by 1.4 red flags, results in a 0.6 percentage point drop in relative delay. Considering tender cancellations, a modest corruption risk change of the conservative scenario (0.6 red flag decline) is associated with a decrease in the cancellation rate of 0.07 percent point. A radical restructuring and a large reduction in corruption risks (1.4 red flags) gives considerably larger results, a potential reduction of cancelled tenders by 0.61 percent point.

Table 12. **Relative delay and tender cancellation impact summary, Colombia (2011-2018)**

Dependent variable	Improvement scenario	CRI change (number of red flags)	Impact
Average relative delay (%)	Conservative scenario (33% CRI decrease)	2.1 -> 1.5	3.43% -> 3.22%
Average relative delay (%)	Aggressive scenario (66% CRI decrease)	2.1 -> 0.7	3.43% -> 2.77%
Average cancellation %	Conservative scenario (33% CRI decrease)	2.2 -> 1.5	6.2% - > 6.13%
Average cancellation %	Aggressive scenario (66% CRI decrease)	2.2 -> 0.7	6.2% - > 5.59%

Figure 24. **Actual and hypothetical estimated relative delay (%), buyer level, aggressive scenario (Colombia, 2011-2018**

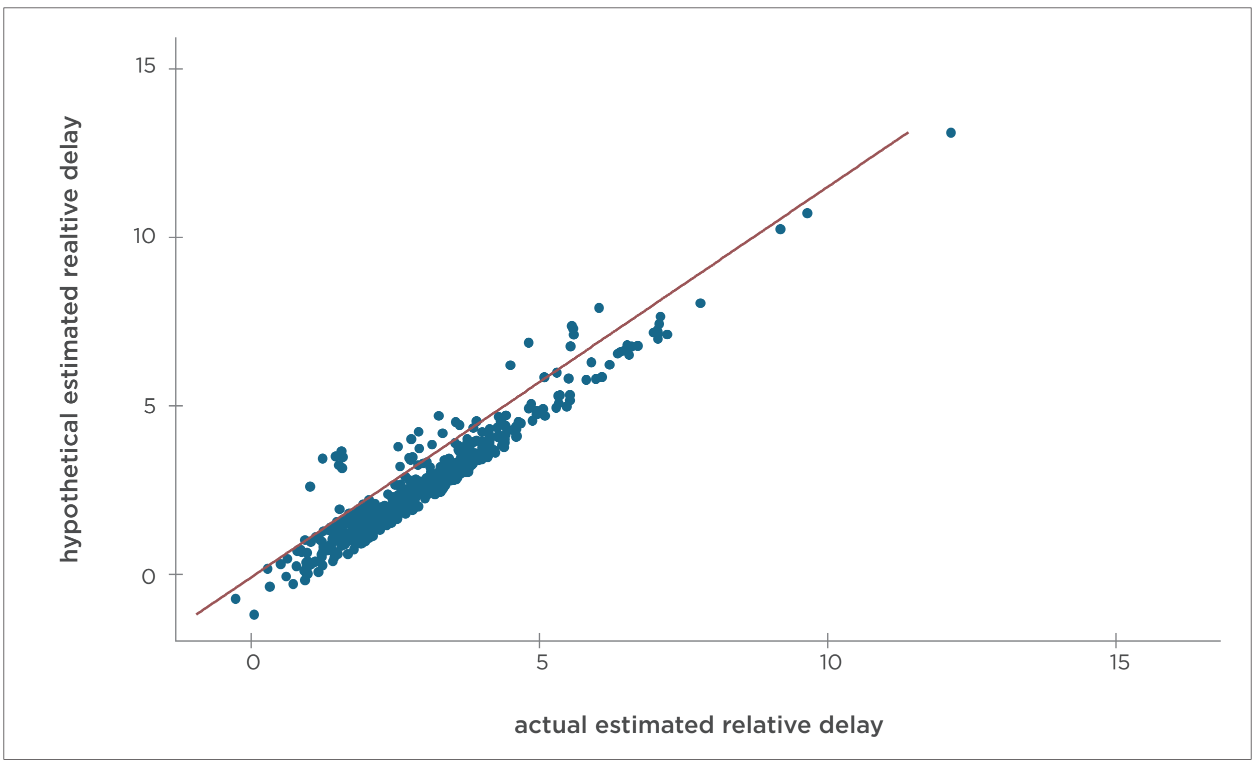
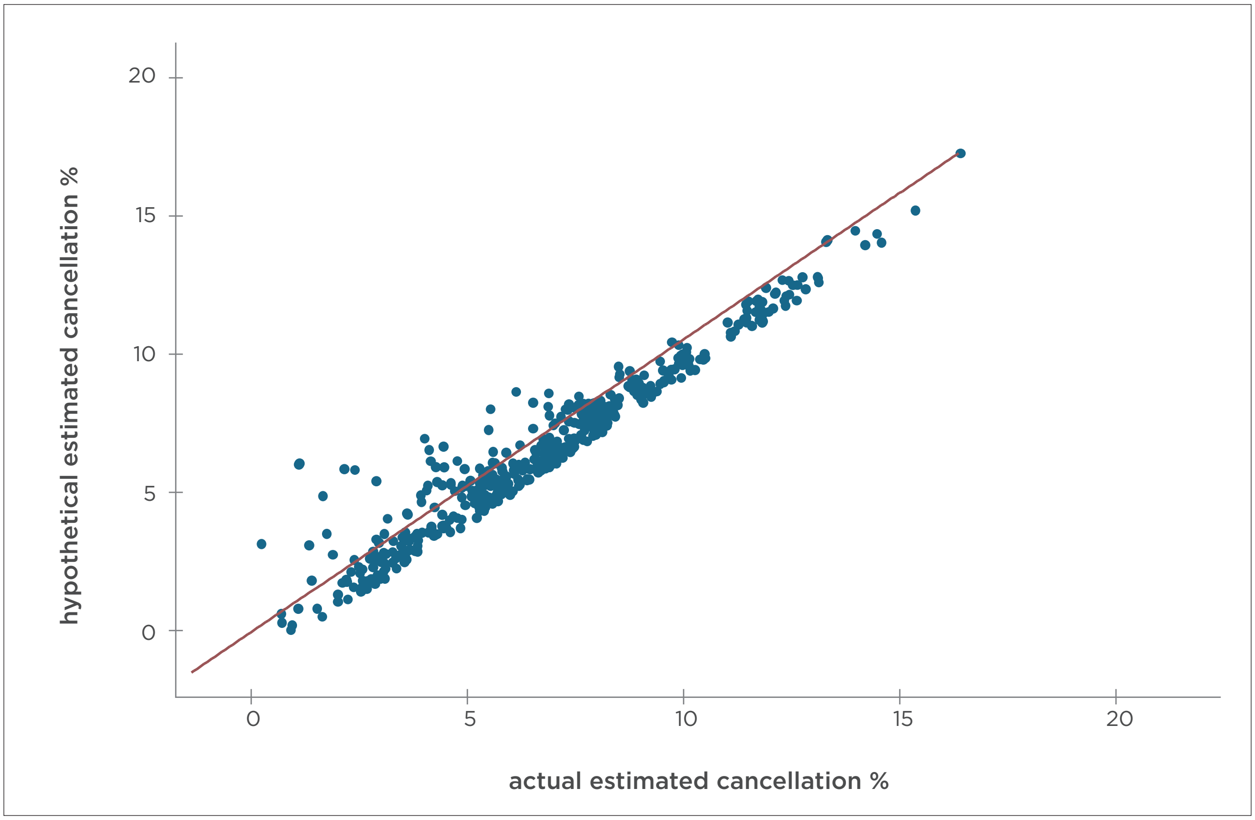


Figure 25: Actual and hypothetical estimated cancellation %, buyer level, aggressive scenario (Colombia, 2011-2018)



5.4 Jamaica

Data description

In Jamaica, the autonomous regulatory agency, the Office of Utilities Regulation, regulates the W&S sector. The National Water Commission is the main provider of drinking water and sewerage services, while there are other smaller suppliers and the National Irrigation Commission on the market (OUR, 2012). In 2015, 92% and 81% of the population had access to improved water and sanitation services, respectively (Bertoméu-Sánchez & Serebrisky, 2018).

The Jamaican database provided by the Office of the Contractor General (http://www.ocg.gov.jm/ocg/view/qca-consol) contains information predominantly on the tendering and contracting phases of public procurement. It includes 141,317 contract-level observations on implemented contracts of public bodies (national, regional, local authorities, public bodies, state companies, independent agencies), which have been reported to the Office of the Contractor General (OCG) by way of Quarterly Contract Award (QCA) Reports since May 1, 2006. Effective July 1, 2012, public bodies are required to report all contracts with a value of J$500,001 or higher. The dataset covers the period from 2006 to 2018 and contains data on the procurement method, number of received and requested tenders, award date, contract description, buyer and supplier ID, contract value and type and the principal site of contract implementation. The missing rate of these variables is considerably low (0%-1%), except for the number of requested tenders (17% missing) and supplier ID (8% missing). Unfortunately, the dataset lacks information on tender submission deadline, supplier and buyer location, as well as contract start and end date, and contains no variables that could be used to measure the corruption risk outcomes used in this report (prices or delays).

On the basis of this national dataset, the contracts related to the W&S sector were marked in two ways. Firstly, the list of names of Jamaican W&S utility companies provided by IBNet was used and the matching buyer names were marked in the procurement dataset. In addition, buyer names were searched to complete the list of relevant buyers with, for example, local utilities that were not included in the IBNet list. The keywords tried to capture the different W&S sector services, such as drainage, sewerage and water systems. To find the most relevant utilities and products, buyer names and product descriptions were harmonized (accents and whitespaces were removed and text was converted into lower case). The selected utilities and their official websites were reviewed. The keyword used for the Jamaican context was "water supply".

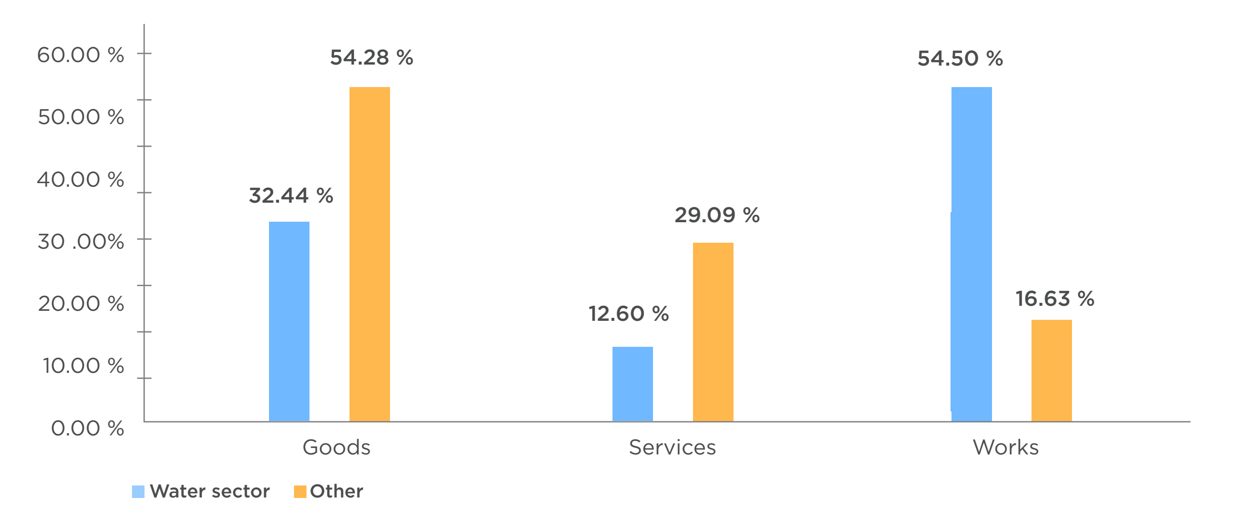
Secondly, a range of keywords was used to search product descriptions in the procurement dataset in order to mark those contracts that are also related to the W&S sector. The keywords used include: *"drainage" and "constr", "water channel", "sanitation" and "constr", "water" and "constr", "water" and "treatmen" and "maint", "water" and "treatmen" and "constr".*

As a result, only 0.27% of contracts (375 contracts) in the dataset were related to the W&S sector, with 131 contracts specifically related to W&S products based on their product name and 241 contracts coming from one W&S utility company called Rural Water Supply (Figure 26).

Figure 26: **Number of W&S sector contracts by using utility buyer names and 'water' search words (Jamaica, 2006-2018)**

Figure 27 shows that most W&S-related contracts go for public works (54.5%), the second biggest sector being goods (32.44%) and only a small portion for services (12.6%). These shares differ significantly from the contract number distribution in all other sectors: the share of public works contracts is roughly three times higher, while services purchases are about three times smaller.

Figure 27: Distribution of awarded contracts in the W&S sector vs. all other sectors (Jamaica, 2006-2018)



Note: Office of the Contractor General data included procurement category information

Corruption Risk Index

A number of corruption risk indicators (red flags) could be calculated and validity tested for the Jamaican dataset, where 0 stands for non-risky behavior, 0.5 indicates a medium risk situation (where applicable), and 1 signifies a corruption risk. In total, four valid risk indicators can be identified (overview in Table 13), with three of them related to the tendering process and one related to supplier risks. The latter indicates the supplier's share in a buyer's total spending in a year.

The three tendering risks are related to different aspects of the procurement process. First, all the different procedure types used in Jamaica were classified into open, limited open and non-open procedure types based on their association with single bidding (See Appendix K for regression details). Please note that we identify red flags (e.g. classify procedure types as non-open) based on their association with non-competitive outcomes such as single bidding in regression analysis. Consequently, the following national procedure type is considered "open", *Open tender*; whereas, these are classified as “limited open”: *International competitive bidding, Local competitive bidding, Limited tender, Selective tender. Lastly, these national procedure types are considered “non-open”: Direct contracting, Electronic direct contracting, and Sole source.*

Second, if the number of requested bids was one or zero, it is considered as high-risk, while requesting between two and five was classified as medium-risk. We expect high-risk features of the procurement process to lead to restricted competition (single bidding) (see Appendix K for regression details). Lastly, a red flag was raised when there was only one bid submitted for a tender (single bidder).

Table 13. Red flag definitions, Jamaica

Indicator group	Indicator name	Indicator definition
Tendering risk	Procedure type	0 = open, competitive procedure 0.5 = procedure with limited competition 1 = non-open procedure (e.g. direct contract-ing)
Tendering risk	Number of requested bids	0 = 6 or more bids requested 0.5 = 2-5 bids requested 1 = 0 or 1 bid requested
Tendering risk	Single bidder contract	0 = more than one bid received 1 = one bid received
Supplier risk	Supplier spending share	The supplier’s share in a buyer’s total spending in a year

Having tested these four indicators for their validity, the composite Corruption Risk Index (CRI) was built as the simple arithmetic average of the individual risk indicators, falling between 0 and 1, with 1 representing the highest observed corruption risk and 0 the lowest. Among other things, the CRI indicator developed here allows for scoring each contract award and identifying those with the highest risk. Figure 28 shows the uneven distribution of risks among contract awards. In simple terms, a contract with the average CRI score has around two red flags out of the four measured red flags present. Half of the contracts have fewer than two red flags, while 35% of them have three to four valid red flags out of four.

Figure 28. CRI distribution of contracts, Jamaica, 2006-2018.

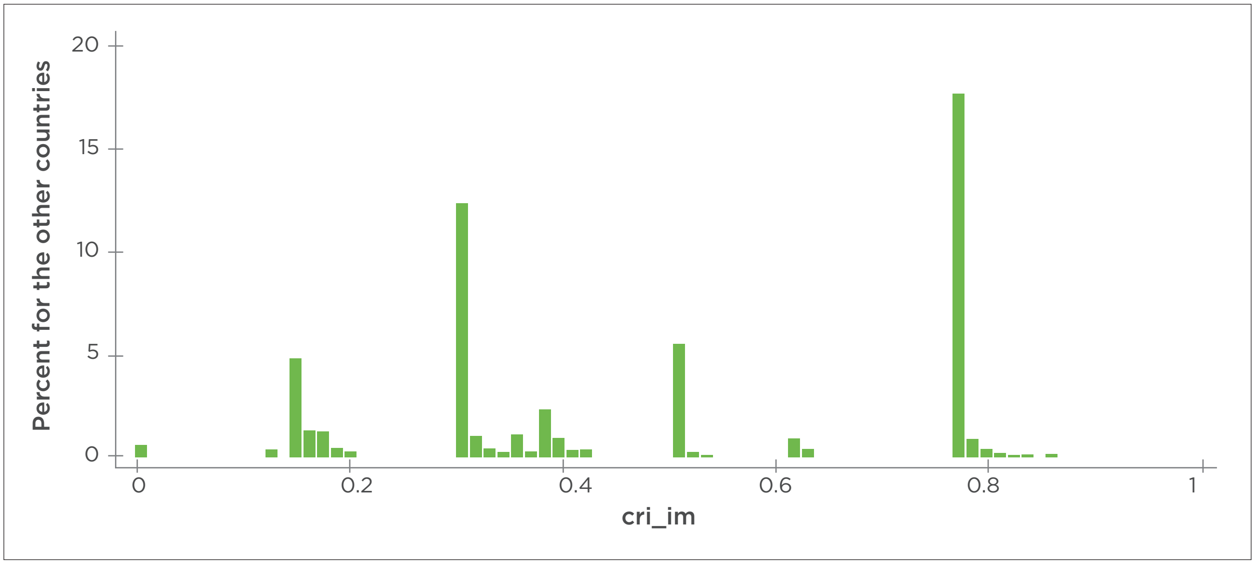


Table 14, Figure 29 and Figure 30 show the difference between W&S contracts and other contracts in CRI distribution. Low CRI values are more frequent for W&S contracts – see the red spikes on the left-hand side of Figure 29.

Table 14. Average of elementary CRI components of Jamaica (2006-2018) (N_{water}=375, N_{all}= 138,758)

	Single bidding	Number of requested bids	Non-open procedure type	Supplier spending share	CRI
W&S sector	35.3%	58.3%	69.7%	6.5%	0.40
Other sectors	55.6%	61.5%	71.2%	4.9%	0.46

Figure 29. Distribution of contracts by CRI values of water sector (1) and all other (0) contracts (Jamaica, 2006-2018)

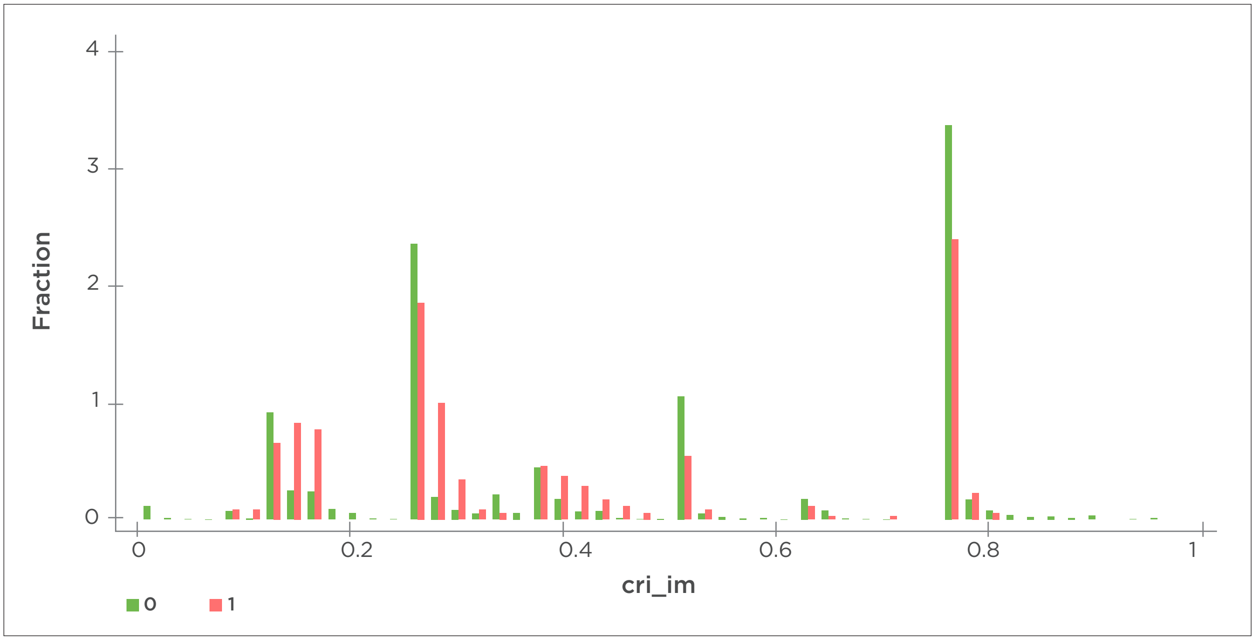
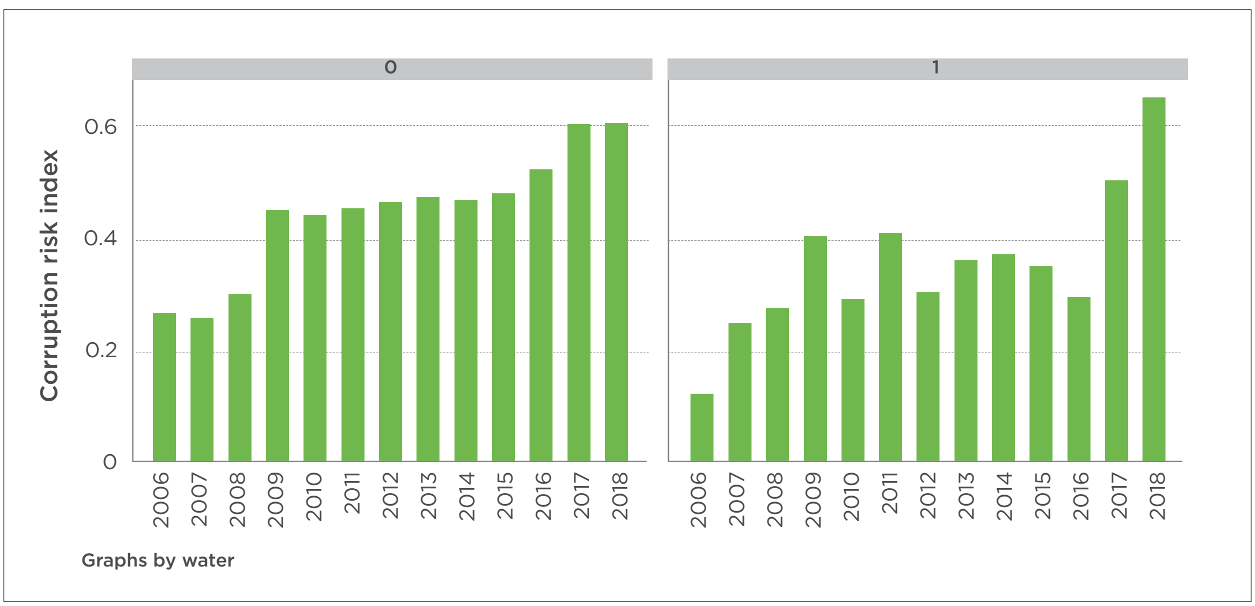


Figure 30: Distribution of contracts by CRI values of the W&S sector (1) and all other (0) contracts (Jamaica, 2006-2018)



Main results

As neither relative prices nor unit prices could be calculated for Jamaican contracts due to missing data, possible price savings were extrapolated based on the average findings we have for other Latin American countries. Because Ecuador and Paraguay are the most comparable to each other in terms of corruption cost analysis and their data is of the highest quality for the W&S sector, the Jamaican estimated price change was calculated based on the average price changes in these two countries.[11]

Table 15 shows the average changes in CRI under the aggressive and conservative scenarios and the corresponding changes in average prices and total spending. A 2-5% price decrease was estimated due to decreasing corruption risks. Nevertheless, please note that a couple of assumptions were used. For example, the relationship between red flags and prices that was found in Ecuador and Paraguay was extrapolated to Jamaica. This relationship holds probably only partly, as the CRI distributions show some differences among countries.

Table 15. Potential savings calculation for water sector contracts, Jamaica (2006-2018)

Savings scenario	CRI change (number of red flags)	Total spending change (million USD)	Average price change (%)
Conservative scenario (33% CRI decrease)	1.6 -> 1.1	23 -> 22.9	-1.5%
Aggressive scenario (66% CRI decrease)	1.6 -> 0.5	23 -> 22.1	-4.9%

11 Unfortunately, there is no other country among our case study countries that would be similar to Jamaica in procurement market structure and institutions; hence, our reliance on data and estimation quality for selecting comparator countries.

5.5 Paraguay

Data description

In Paraguay, the main individual service provider is the state-owned water and sanitation utility, ESSAP S.A. (Empresa de Servicios Sanitarios del Paraguay S.A.), sharing the sector with local water user committees and private operators. The sector is regulated by the autonomous entity, ERSSAN (Ente Regulador de Servicios Sanitarios) (World Bank, 2009). Close to 95% of the population had access to improved water and 85% to sanitation services in 2015, respectively (Bertoméu-Sánchez & Serebrisky, 2018).

The Paraguayan dataset consists of a combination of three sources: a) OCDS (Open Contracting Data Standard) publication, b) yearly CSV (Comma Separated Values) publications on the public procurement portal[12], and c) bidder data downloaded from https://contrataciones.gov.py/. Although the OCDS publication helps to create the main chunk of the dataset, key variables had to be added from the two other sources, such as the number of bids or procedure type. The combined dataset contains 540,537 observations defined on the level of submitted bids for the years 2010-2018. The dataset contains purchases of federal, state and municipal governments, federal and local bodies, national funds and banks and other independent entities.

In addition, the number of bids was obtained by calculating the number of companies listed in the CSV publication that can be downloaded at the *“Oferentes Presentados”* section of each tender. Using this variable

12 https://contrataciones.gov.py/datos/convocatorias

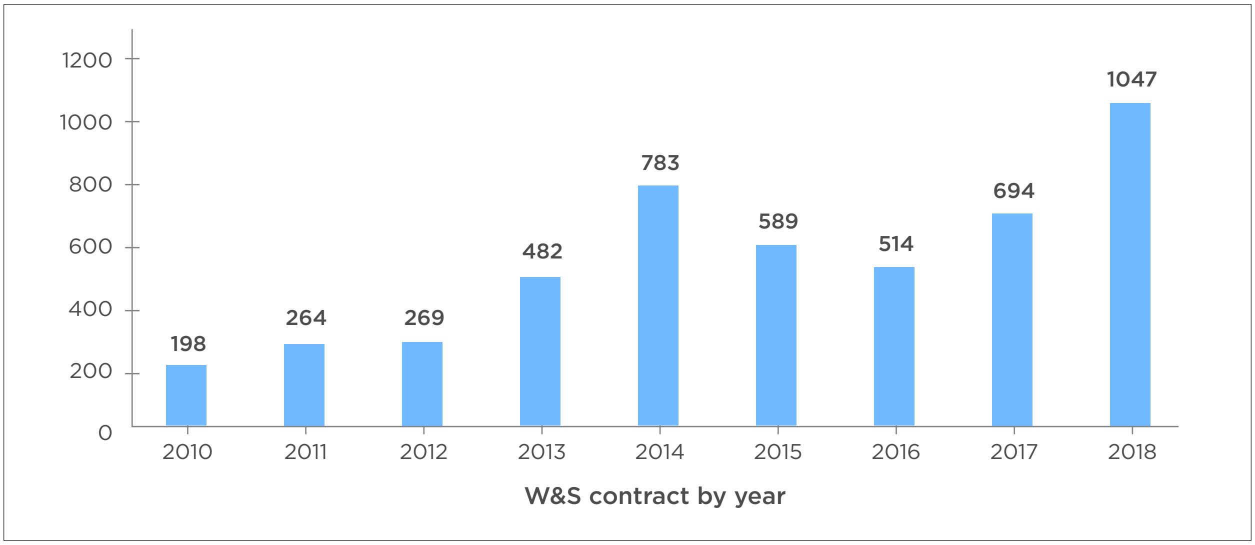
for the purpose of this study presented a couple of challenges. First, the number of bids can only be calculated at the tender level, whereas, multiple contracts can be awarded by each tender. Second, as interviews clarified, public buyers are not obliged to publish all bids on the *Contrataciónes* website; it is enough to make the winner companies' names public. This means that the share of tenders awarded without competition – for example, tenders concluding one contract with only one bid received or concluding three contracts to three different companies and showing three received bids – will be most likely overestimated.

On the basis of this combined national dataset, bids related to the W&S sector were filtered in two ways. First, the list of names of Paraguayan W&S utility companies provided by IBNet was used and the matching buyer names were marked in the procurement dataset. In addition, buyer names were searched using a number of keywords related to W&S to complete the list of relevant buyers with, for example, local utilities that were not included in the IBNet list. The keywords tried to capture the different dimensions of the W&S sector, such as drainage, sewerage and water systems. To find the most relevant utilities and products, buyer names and product descriptions were harmonized (accents and whitespaces were removed and text was converted into lower case). The selected utilities and their official website were reviewed. The keywords used for the Paraguayan context include: *"servicios sanitarios", "alberdi", "san bernardino", "erssan".*

Second, a range of keywords was used to search product descriptions in the procurement dataset in order to mark those bids that are also related to the W&S sector. The keywords used include: *"sistema" and "agua", "saneamiento" and "agua", "cuenca" and "agua", "alcantarillado" and "agua", "drenaje" and "agua".*

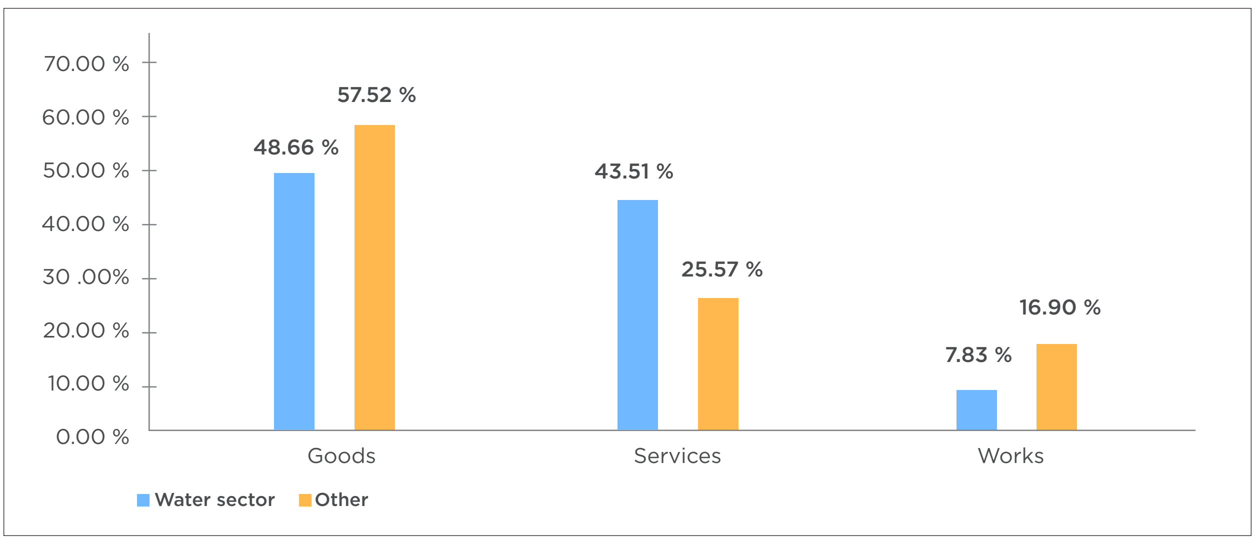
The number of bids marked according to these two methods amounted to 4,840, including all bids specifically related to W&S products based on their tender title (around 1,300 contracts) and all contracts of W&S utility companies (around 3,500 contracts) (Figure 31). This dataset translates into 1,510 awarded contracts altogether.

Figure 31: **Number of W&S sector contracts by using utility buyer names and 'water' search words (Paraguay, 2010-2018)**



Most of the W&S sector-related contracts are for goods (48.7%) and services (43.51%). Contracts for public works account for only 7.83% in the W&S sector and 16.9% in other sectors, as shown in Figure 32.

Figure 32: **Distribution of awarded contracts in the W&S sector (1) vs. all other sectors (0) (Paraguay, 2010-2018)**



Note: DNCP data set contained UNSPSC item classification codes

Corruption Risk Index

A number of corruption risk indicators (red flags) could be calculated and validity tested for the Paraguayan dataset, where 0 stands for non-risky behaviour, 0.5 indicates a medium-risk situation (where applicable), and 1 signifies a high corruption risk. In total, nine risk indicators were identified (overview in Table 16), with seven of them related to the tendering process, and two based on information about supplier company risks. The latter indicates the supplier's share in a buyer's total spending in a year, and the winning probability of companies was also calculated, with a probability of 34-75% considered medium risk, and a winning probability of 76-100% (i.e. a company wins three out of four times when it bids in a public tender) raising a high-risk red flag.

The five tendering risks are related to different aspects of the procurement process. First, all the different procedure types used in Paraguay were classified into open, limited open and non-open procedure types based on their association with single bidding (See Appendix I for regression details). Please note that we identify red flags (e.g. classify procedure types as non-open) based on their association with non-competitive outcomes such as single bidding in regression analysis. Consequently, the following national procedure types are considered "open": *Acuerdo internacional, Acuerdo nacional, Licitación Internacional, Licitación Pública Nacional, Licitación Pública Internacional, Licitación Pública Nacional, Licitación pública nacional por SBE sistema nacional bid bienes comunes.* The following procedures were classified as "limited open": *Concurso de ofertas, Licitación por concurso de oferta sistema nacional bid obras simples, Obras simples.* Lastly, these national procedure types are considered "non-open": *Locación de inmuebles, Contratación por excepción, Contratación directa.*

Second, not publishing the call for tenders was considered a red flag. Third, the length of a tender description was counted, as exceedingly long ones can indicate that a tender was tailored to a pre-selected company. Hence, a description length of more than 515 characters is considered high-risk, and a description length of 40-515 characters is considered medium-risk. The number of accompanying documents published was also counted, with a number of fewer than 14 signifying a high-risk situation, and a number between 14-18 documents published indicating a medium risk. For both indicators, the exact thresholds were defined so that the risk categories predict single bidding probability the best, because we expect high-risk features of the procurement process leading to restricted competition (single bidding) (See Appendix I for regression details).

Fourth, the length of the period given for bid submission and the period of time it takes for the procuring body to announce a decision were measured. In the case of Paraguay, submission periods of fewer than 13 days or a period of 31-47 days are associated with a high risk of corruption, while submission periods between 13-30 days carry a medium corruption risk. For decision periods, those that are shorter than 23 days raise a red flag and decision periods between 23-64 days also pose medium corruption risk. Once again, the exact thresholds were identified using regression analysis as reported in Appendix I. Lastly, a red flag was raised when there was only one bid submitted for a tender (single bidder).

Table 16. **Red flag definitions, Paraguay**

Indicator group	Indicator name	Indicator definition
Tendering risk	Procedure type	0 = open, competitive procedure 0.5 = limited open procedure 1 = non-open procedure (e.g. direct contracting)
Tendering risk	Lack of call for tender publication	0 = call for tenders published 1 = call for tenders not published
Tendering risk	Tender description length	0 = number of characters =<39 0.5= number of characters between 40-515 1=number of characters >515
Tendering risk	Number of related documents published	0 = number of documents =>19 0.5 = number of documents between 14-18 1 = number of documents <14
Tendering risk	Length of submission period	0 = submission period >=48 days 0.5 = submission period between 13-30 days 1 = submission period <13 days OR between 31-47 days
Tendering risk	Length of decision period	0 = decision period >=65 days 0.5 = decision period between 23-64 days 1 = decision period <23 days
Tendering risk	Single bidder contract	0 = more than one bid received 1 = one bid received
Supplier risk	Winning probability	0 = winning probability =<33% 0.5 = winning probability between 34-75% 1= winning probability between 76-100%
Supplier risk	Supplier spending share	The supplier's share in a buyer's total spending in a year

Having tested these nine indicators for their validity, the composite Corruption Risk Index (CRI) was built as the simple arithmetic average of the individual risk indicators, falling between 0 and 1, with 1 representing the highest observed corruption risk and 0 the lowest. Among other things, the CRI indicator developed here allows for scoring each contract award and identifying those with the highest risk. Figure 33 shows the approximately normal distribution of risks among contract awards. In simple terms, a contract with the average CRI score has around four red flags out of the nine measured red flags present. Forty-three percent of contracts are considered to have lower risk of corruption with zero to three red flags, while the majority of the contracts (50%) have four to six red flags present, meaning a considerable risk of corruption.

Figure 33. **CRI distribution of contracts, Paraguay, 2010-2018.**

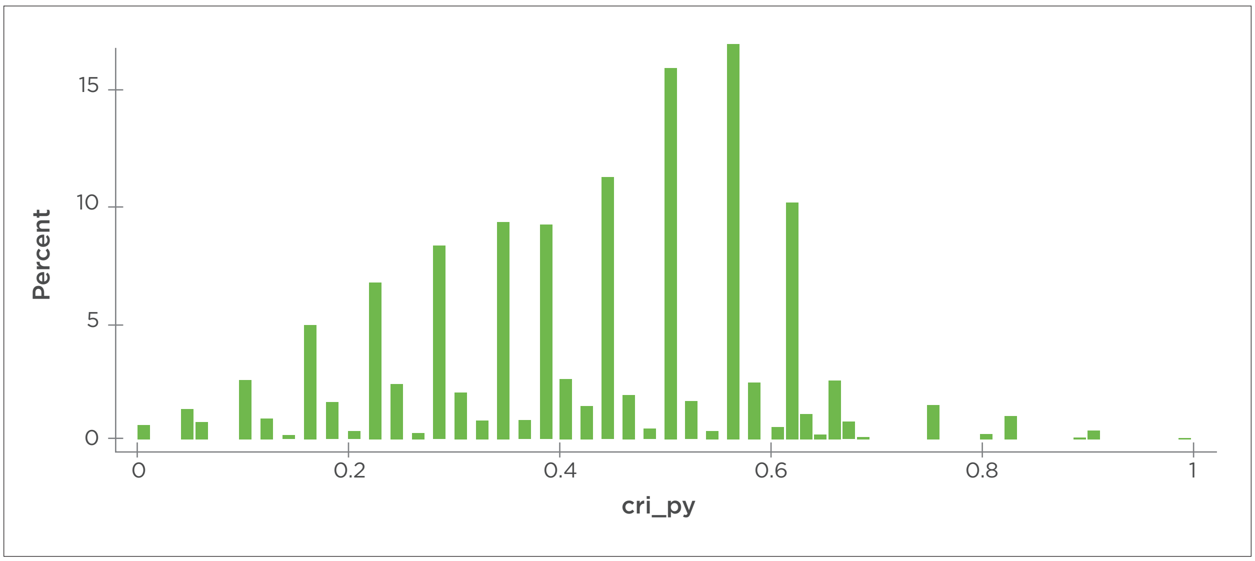


Table 17. **Average of elementary CRI components in Paraguay (2010-2018) Nw&s= 1,510, Nother=142,106)**

	Single bidding	No call for Tender	Non-open procedure type	Short sub-mission period	Short decision period	Descrip-tion length	Documents	Winning proba-bility	Supplier spending share	CRI
W&S sector	62.1%	0.79%	59.6%	14.1%	39.3%	45.9%	67.5%	52.8%	2.9%	0.38
Other sectors	58%	6.17%	71.1%	8.7%	52.8%	50%	72.5%	53.6%	3.6%	0.43

Table 17, shows the difference between W&S contracts and other contracts in CRI distribution. Low CRI values are more frequent for water and sanitation contracts.

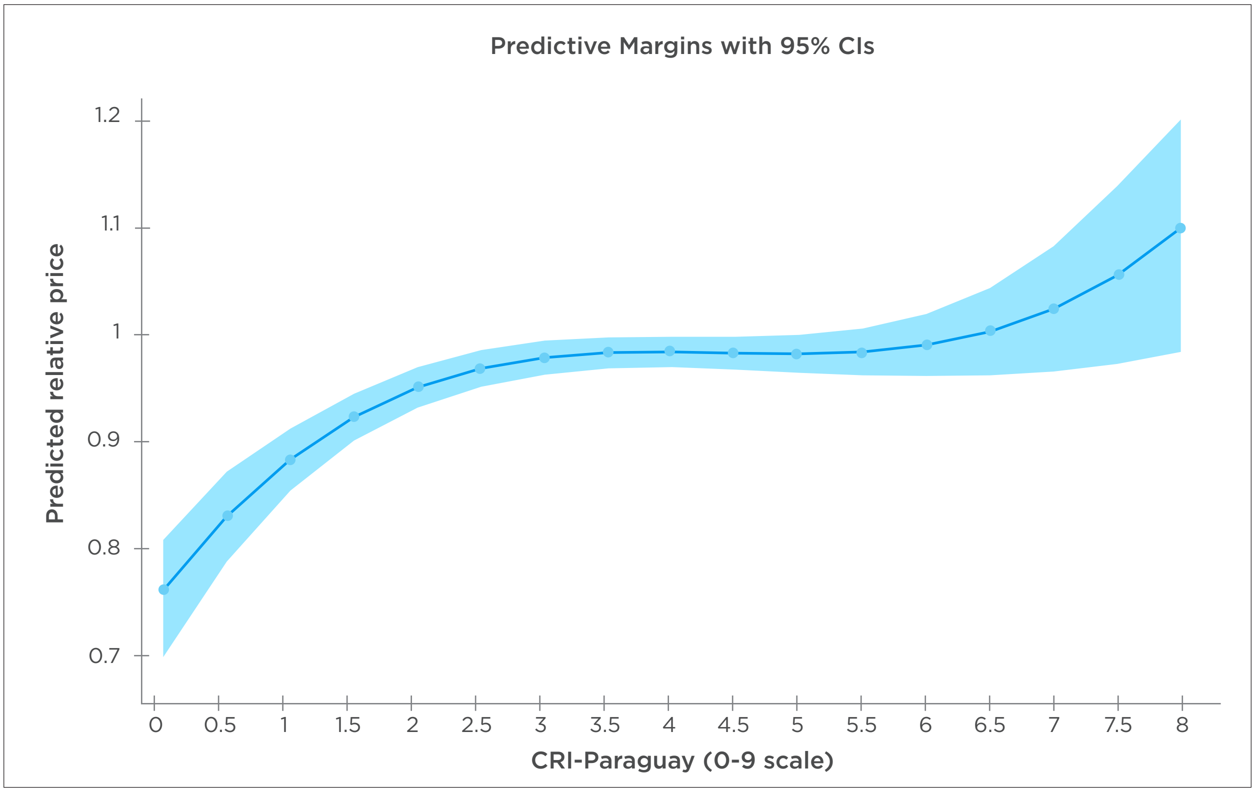
Main results

This section spells out relative price models and potential cost savings. As was explained in the data description section for Paraguay, there was data on 1,510 contract awards related to the W&S sector. Out of these, only 1,293 contracts have all the relevant variables for full regression analysis of the CRI and relative price relationship.

Simple OLS regression models were built explaining relative prices with the CRI while controlling for contract value, product code, buyer type and year. Relative price is defined as the ratio between the awarded contract value and the initially estimated contract value. Hence, higher relative prices mean more expensive contracts and lower relative prices signify cheaper purchases. The CRI was entered in the regressions in different versions in order to check for any likely non-linear relationships and interactions with the market. In general, we expected that across most of the sample, more red flags (higher CRI) are associated with higher relative prices. In comparison with results for Uruguay and Mexico, public works contracts could be also incorporated, not only goods. This is because relative prices can be consistently analyzed across a wide variety of markets, unlike unit prices, which work best for standardized goods.

The explanatory power of our preferred specification is high, R^2=0.27, (Model 3 in Table D1). The identified relationship between CRI and relative prices is non-linear, as shown in Figure 34. Between zero to three red flags, there is a very strong increase in predicted relative prices, then the relationship is largely flat for the three to six red flags range. For contracts with very many red flags, six or above, a steep increase in predicted relative prices can be observed; however, the prediction accuracy decreases predominantly due to a significantly smaller sample size for this high-risk domain. As a simple measure of effect size, in the linear model, an additional red flag is associated with 1.7% higher prices. The identified non-linear impact curve with large uncertainty on the upper end suggests that a policy strategy aiming to reduce corruption with the greatest cost impact should focus on average risk contracts. In other words, the payoffs are greatest to targeting moderate corruption risk contracts of about three to six red flags by lowering their risk close to minimal, zero to two red flags. See Appendix D for full regression tables with various alternative specifications.

Figure 34. **Predicted relative price by CRI values[13] (Paraguay, 2010-2018)**



Potential cost savings

Once again, the preferred non-linear regression (Model 3) can be used to define sector-wide reforms, which lower CRI across all contracts and hence impact on the whole distribution of relative prices. Two scenarios can be investigated, a conservative and aggressive scenario, stipulating different degrees of average CRI decrease. In addition to defining the corruption risk reduction scenarios and combining them with regression predictions, the total value of contracts influenced was also looked at in order to attach a total price tag to the estimated corruption risk improvements (Table 18). A two and seven percentage point decrease in relative prices was estimated due to decreasing corruption risks under the conservative and aggressive scenarios, respectively. These translate into 4-17 million USD total savings over the 2010-2018 period. The predicted changes in the relative prices under the conservative scenario

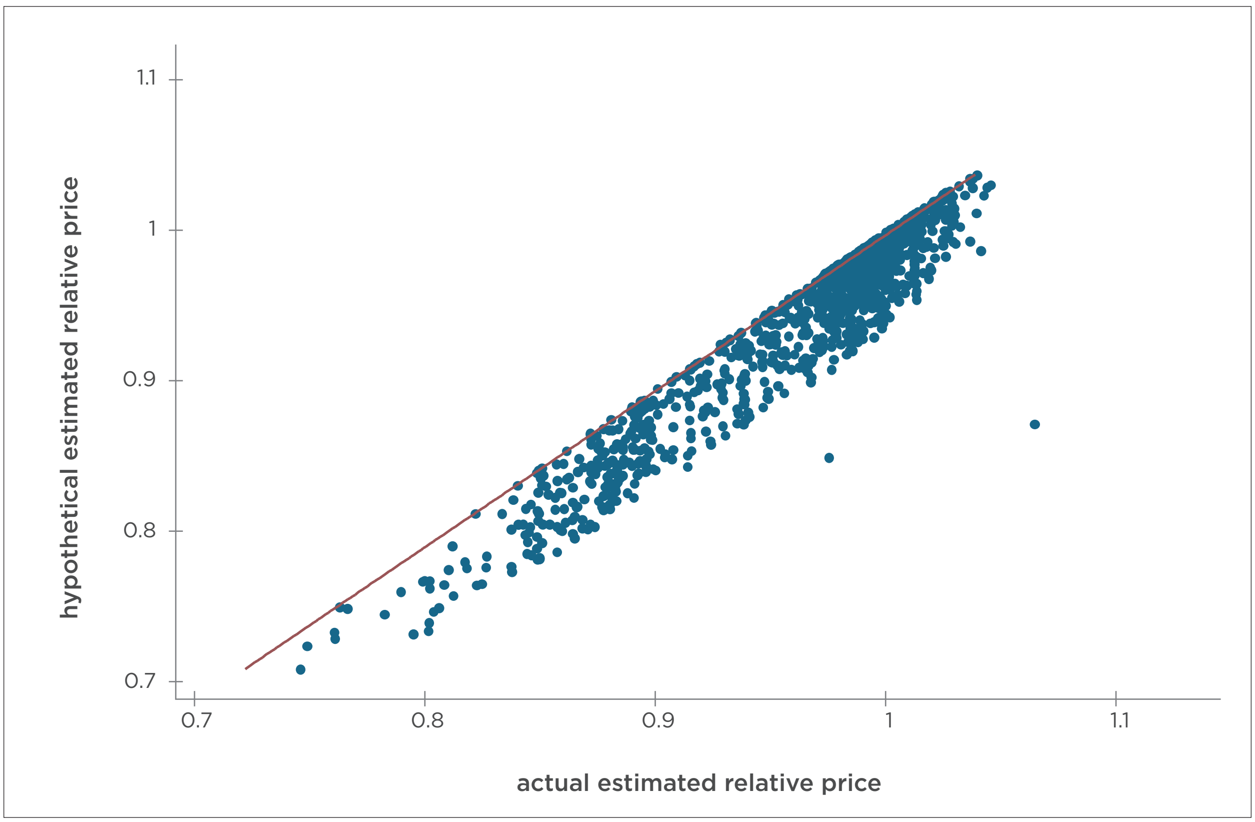
13 One unit in the x-axis can be interpreted as one additional red flag – as the CRI is built up from nine components.

are also visually represented in Figure 35. It shows how unit prices would change if CRI is reduced on average by 33%, or 2.4 red flags (with random variation around the mean), while holding all other contract characteristics constant.

Table 18. **Price savings summary, Paraguay (2010-2018)**

Savings scenario	CRI change (number of red flags)	Total spending change (million USD[14])	Average relative price change
Conservative scenario (33% CRI decrease)	3.5 -> 2.4	228 -> 224	0.97 -> 0.95
Aggressive scenario (66% CRI decrease)	3.5 -> 1.2	228 -> 211	0.97 -> 0.9

Figure 35. **Actual and hypothetical estimated relative prices, Paraguay (2010-2018), conservative scenario**



14 A uniform PYG/USD exchange rate of 6458 was applied

5.6 Ecuador

Data description

In Ecuador, Subsecretaría de Agua Potable y Saneamiento Básico (Subministry of Potable Water and Basic Sanitation) is responsible for the regulation of W&S services and municipalities, municipal public companies for the management of service provision. The two largest service providers are EPMAPS Agua de Quito and the private company, Interagua in Guayaquil (World Bank, 2004). In 2015, 87% and 85% of the population had access to improved water and sanitation services, respectively (World Bank, 2017).

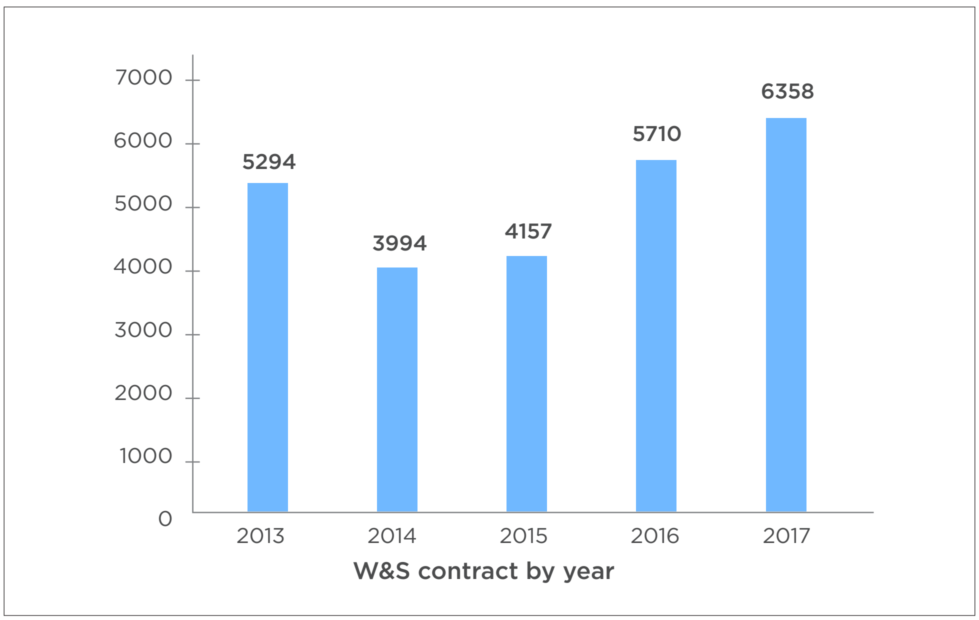
The Ecuadorian database is based on the national public procurement portal https://www.compraspúblicas.gob.ec/ProcesoContratación/compras/. It provides around two million observations, with most of the key variables and basic controls available, including purchases of national authorities, public companies, public bodies and decentralized autonomous governments.

On the basis of this dataset, contracts related to the W&S sector were marked in two ways. First, the list of names of Ecuadorian W&S utility companies provided by IBNet was used and the matching buyer names were marked in the procurement dataset. In addition, buyer names were searched using a number of keywords related to W&S to complete the list of relevant buyers with, for example, local utilities that were not included in the IBNet list. The keywords tried to capture the different dimensions of the W&S sector, such as drainage, sewerage and water systems. To find the most relevant utilities and products, buyer names and product descriptions were harmonized (accents and whitespaces were removed and text was converted into lower case). The selected utilities and their official website were reviewed. The keywords used for the Ecuadorian context include: *"agua potab" and "alcantarillado", or "agua potab" and "saneamiento".*

Second, a range of keywords was used to search the item descriptions in the procurement dataset in order to mark those contracts that are also related to the W&S sector. The keywords used include: *"sistema" and "agua", "saneamiento", "cuenca", "alcantarillado", "drenaje", "sanitarios" and "agua", "fontaneria" and "agua", or "tuberia" and "agua".*

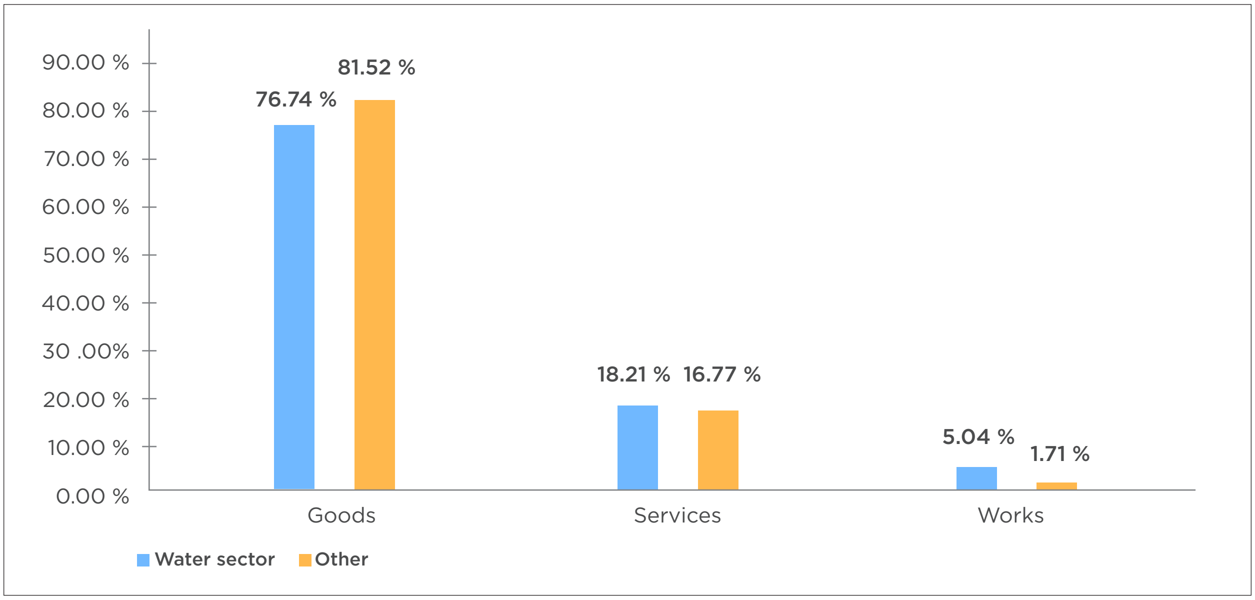
The number of contracts marked according to these two methods amount to 25,513, including all contracts specifically related to W&S products based on their tender title (around 1,500 contracts) and all contracts of W&S utility companies (around 24,000 contracts) (Figure 36).

Figure 36: Number of W&S contracts by using utility buyer names and 'water' search words (Ecuador, 2013-2017)



The water sector-related contracts are mainly for goods (76.74%) and, to a smaller degree, for services (18.21%). Public works contracts account for a very small portion of the total number of contracts in the W&S sector (5.04%), and other sectors account for an even smaller portion (1.71%), as shown in Figure 37.

Figure 37: **Distribution of awarded contracts in the water sector (1) vs. all other sectors (0) (Ecuador, 2013-2017)**



Note: SOCE data contained information on procurement category

Corruption Risk Index

A number of corruption risk indicators (red flags) could be calculated and validity tested for the Ecuadorian dataset, where 0 stands for non-risky behavior, 0.5 indicates a medium-risk situation (where applicable), and 1 signifies a high corruption risk. In total, seven risk indicators were identified (overview in Table 19), with five of them related to the tendering procedure, and two based on information related to supplier risks. The latter indicates the supplier's share in a buyer's total spending in a year, and whether a supplier is registered in the same county as a buyer.

The five tendering risks are related to different aspects of the procurement process. First, all the different procedure types used in Ecuador were classified into open, limited open and non-open procedure types based on their association with single bidding (See Appendix J for regression details). Please note that we identify red flags (e.g. classify procedure types as non-open) based on their association with non-competitive outcomes, such as single bidding, in regression analysis. Consequently, the following national procedure types are considered open: *Adquisición de bienes inmuebles, Arrendamiento de bienes inmuebles, Concurso Público, Cotización, Ferias Inclusivas, Licitación, Licitación de Seguros, Lista corta, Subasta Inversa Electrónica.* The following procedure type is classified as limited open: *Catálogo Electrónico.* Lastly, these national procedure types are considered non-open: *Asesoría y Patrocinio Jurídico, Bienes y Servicios únicos, Comunicación Social, Cont. De Instituciones financieras y de Seguros del Estado, Contratación de Seguros, Contratación directa, Contratación Directa por Terminación Unilateral, Contratación interadministrativa, Contrataciones con empresas públicas internacionales, Giro específico del negocio de empresas públicas, Licitación, Licitación de Seguros, Lista corta, Menor Cuantía, Obra artística, científica o literaria, Publicación Especial, Repuestos o Accesorios, Subasta Inversa Electrónica, Transporte de correo interno o internacional.*

Second, not publishing the call for tenders was considered a red flag. Third, the length of the period given for bid submission and the period of time it takes for the procuring body to announce a decision were measured. In the case of Ecuador, submission periods of fewer than 10 days or more than 65 days are associated with a high risk of corruption, while submission periods between 10-25 days carry a medium corruption risk. For decision periods, those that are shorter than seven days raise a red flag and decision periods between eight and 11 days also signify medium corruption risk. In both cases, the exact thresholds were defined so that the risk categories predict single bidding probability the best, because we expect high risk features of the procurement process to lead to restricted competition (single bidding) (See Appendix J for regression details). Lastly, a red flag was raised when there was only one bid submitted for a tender (single bidder).

Table 19. Red flag definitions, Ecuador

Indicator group	Indicator name	Indicator definition
Tendering risk	Procedure type	0 = open, competitive procedure 0.5 = limited open procedure 1 = non-open procedure (e.g. direct contracting)
Tendering risk	Lack of call for tender publication	0 = call for tenders published 1 = call for tenders not published
Tendering risk	Length of submission period	0 = submission period between 26-65 days 0.5 = submission period between 10-25 days 1 = submission period <10 days OR >65 days
Tendering risk	Length of decision period	0 = decision period >12 days 0.5 = decision period between 8-11 days 1 = decision period <7 days
Tendering risk	Single bidder contract	0 = more than one bid received 1 = one bid received
Supplier risk	Same location of buyer and supplier	0 = company not registered in same county as buyer 1 = company registered in same county as buyer
Supplier risk	Supplier spending share	The supplier's share in a buyer's total spending in a year

Having tested these seven indicators for their validity, the composite Corruption Risk Index (CRI) was built as the simple arithmetic average of the individual risk indicators, falling between 0 and 1, with 1 representing the highest observed corruption risk and 0 the lowest. Among other things, the CRI indicator developed here allows for scoring each contract award and identifying those with the highest risk. Figure 38 shows the distribution of risks among contract awards with two spikes suggesting two major corruption risk strategies identified in Ecuador. In simple terms, a contract with the average CRI score displays two to three red flags out of the seven measured red flags. The distribution of CRI scores is rather flat in Ecuador, with two peaks. One is closer to 0, presenting low, close-to-no risk of corruption; this is the case for most of the contracts (50%). One-quarter of the contracts have half of the seven red flags present.

Figure 38. CRI distribution of contracts, Ecuador, 2013-2017.

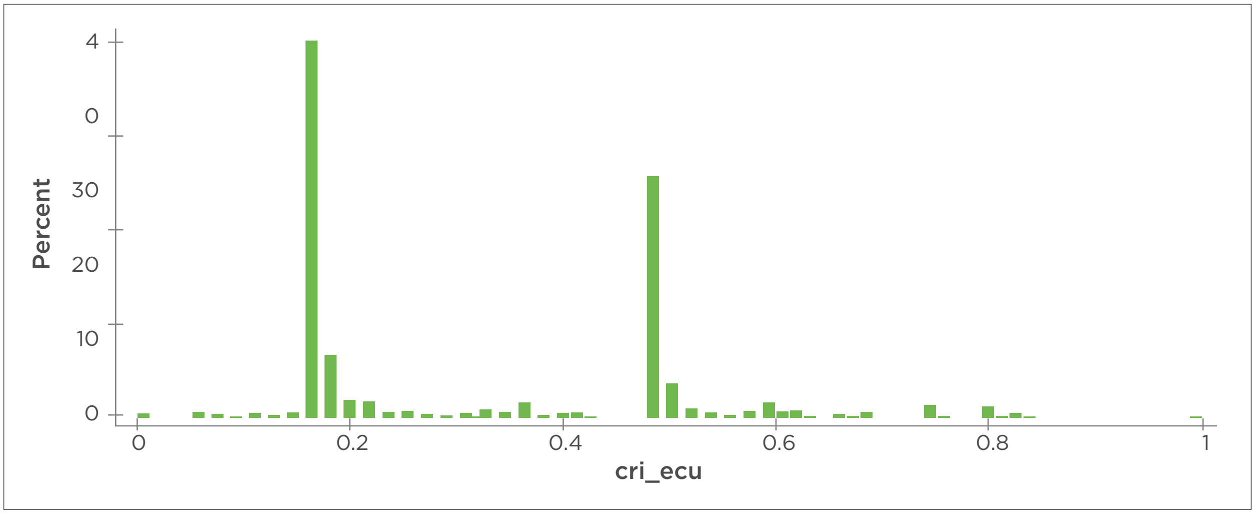


Table 20: Average of elementary CRI components in Ecuador (2013-2017) Nw&s= 25,747 , Nother=1,563,274)

	Single bidding	No call for Tender	Non-open procedure type	Short submission period	Short decision period	Same location	Supplier spending share	CRI
W&S sector	63.8%	23.3%	51.1%	46.9%	15.7%	38.5%	2.96%	0.32
Other sectors	71.1%	18.8%	51.9%	56.7%	22.1%	40.1%	3.37%	0.33

Table 20 shows the difference between W&S contracts and other contracts in CRI distribution. Low CRI values are more frequent for utility contracts.

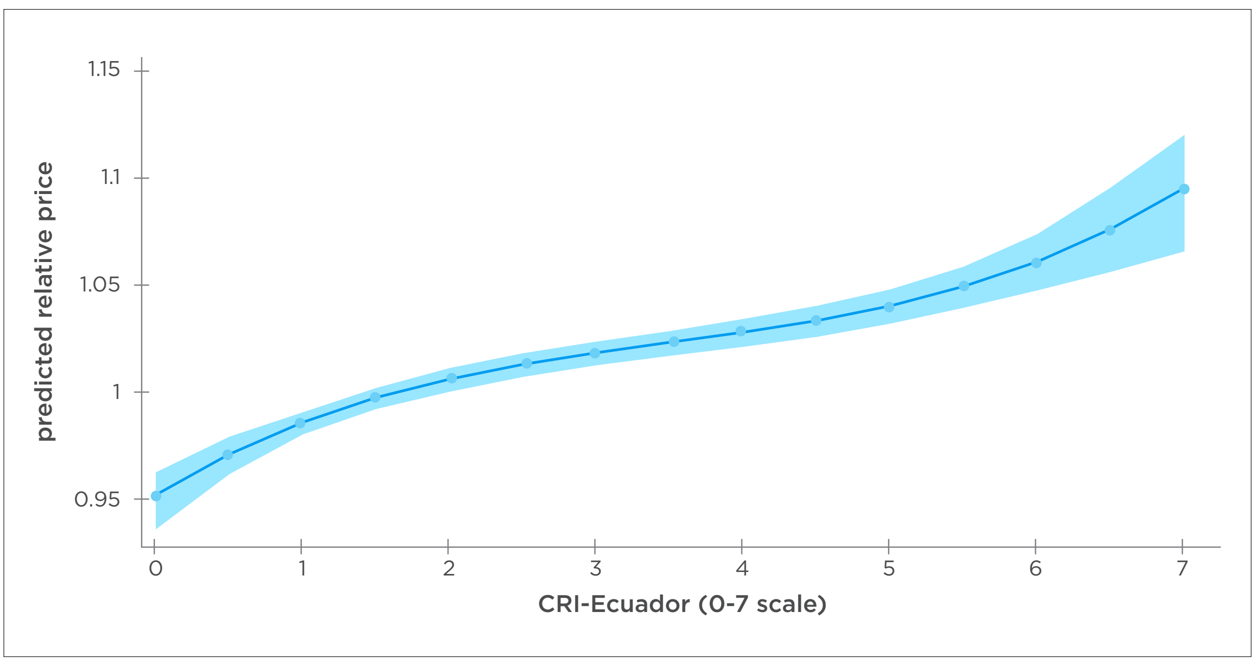
Main results

This section spells out relative price models and potential cost savings. As was explained in the data description section, there was data on 25,510 contract awards related to the W&S sector. Out of these, only 25,454 contracts have all the relevant variables for full regression analysis of the CRI and relative price relationship.

Simple OLS regression models were built, explaining relative prices with the CRI while controlling for contract value, product code, product type, buyer type, buyer location and year. Relative price is defined as the ratio between the awarded contract value and the initially estimated contract value. Hence, higher relative prices mean more expensive contracts, and lower relative prices mean cheaper purchases. The CRI was entered in the regressions in different versions in order to check for any likely non-linear relationships and interactions with market. In general, it is expected that across most of the sample, more red flags (higher CRI) are associated with higher relative prices. In comparison with results from Uruguay and Mexico, public works contracts can be also incorporated, not only goods. This is because relative prices can be consistently analyzed across a wide variety of markets, unlike unit prices, which work best for standardized goods.

The explanatory power of our preferred specification is high, $R^2=0.24$, (Model 2 in Table E1, Appendix E). The identified relationship between CRI and relative prices is non-linear, as shown in Figure 39. Between zero to two red flags, there is a somewhat stronger increase in predicted relative prices, then the relationship is a little less steep for the two to five red flags range. For contracts with very many red flags, five or above, a steeper increase in predicted relative prices is again observed; however, prediction accuracy decreases predominantly due to the smaller sample size for this high-risk domain. As a simple measure of effect size, in the linear model, an additional red flag is associated with 1.4% higher prices. While the identified impact curve is non-linear, it is approximately close to a linear relationship; therefore, targeting any portion of the corruption risk distribution is expected to yield similar price savings. See appendix E for full regression tables with various alternative specifications.

Figure 39. **Predicted relative price in Ecuador (2013-2017) by CRI values**[15]



Potential cost savings

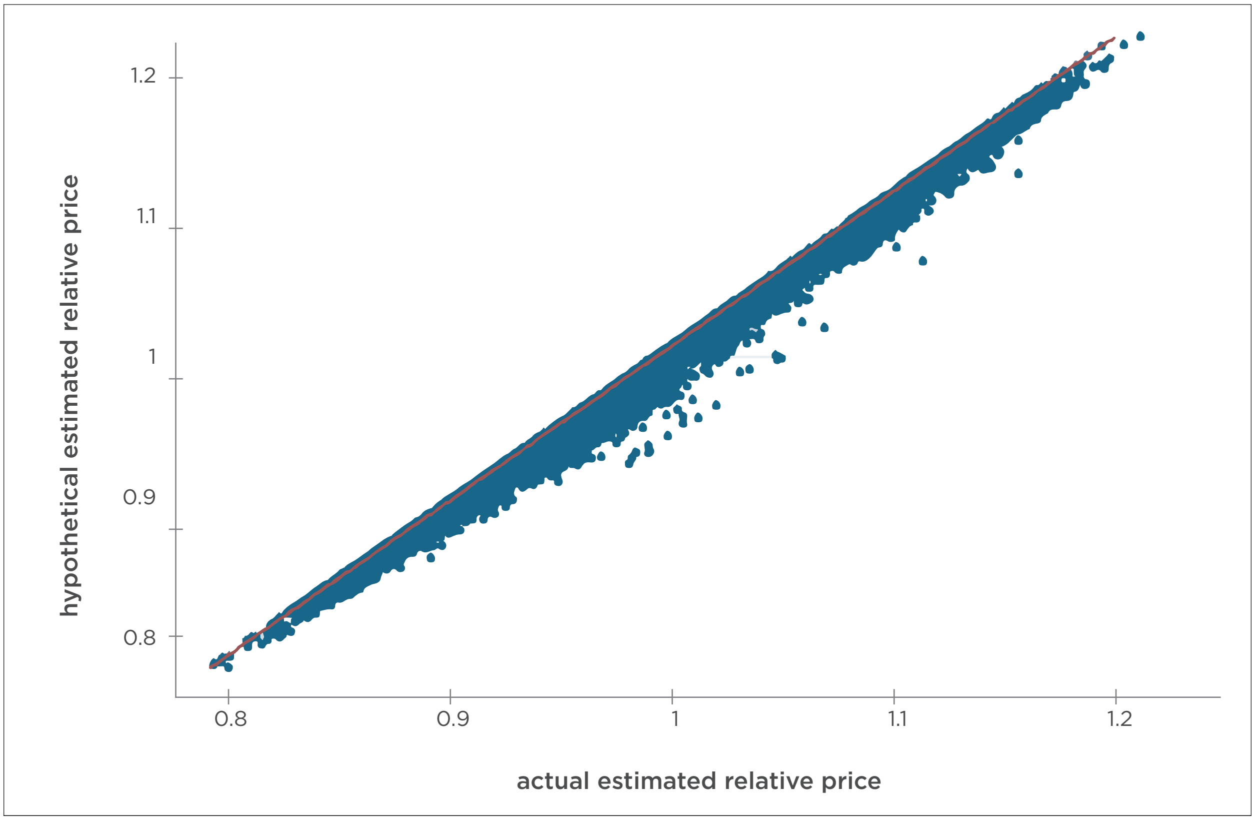
Once again, the preferred non-linear regression can be used to define sector-wide reforms that lower CRI across all contracts and thus impact the whole distribution of relative prices. Two scenarios were inspected, a conservative and aggressive scenario, stipulating different degrees of average CRI decrease. In addition to defining the corruption risk reduction scenarios and combining them with regression predictions, the total value of contracts influenced was also examined in order to attach a total price tag to the estimated corruption risk improvements (Table 21). In Ecuador, a one and three percentage point decrease was estimated in relative prices due to decreasing corruption risks under the conservative and aggressive scenarios, respectively. These translate into 9-21 million USD total savings over the 2013-2017 period. The predicted changes in the relative prices under the conservative scenario are also visually represented in Figure 40, which shows how unit prices would change if CRI is reduced on average by 33% or 1.6 red flags (with random variation around the mean), while holding all other contract characteristics constant.

Table 21. Price savings summary, Ecuador (2013-2017)

Savings scenario	CRI change (number of red flags)	Total spending change (million USD)	Average relative price change
Conservative scenario (33% CRI decrease)	2.3 -> 1.6	820 -> 811	1.01 -> 1.00
Aggressive scenario (66% CRI decrease)	2.3 -> 0.8	820 -> 799	1.01 -> 0.98

15 One unit in the x-axis can be interpreted as one additional red flag – as the CRI is built up from seven components.

Figure 40. Actual and hypothetical estimated relative prices, Ecuador (2013-2017), conservative scenario

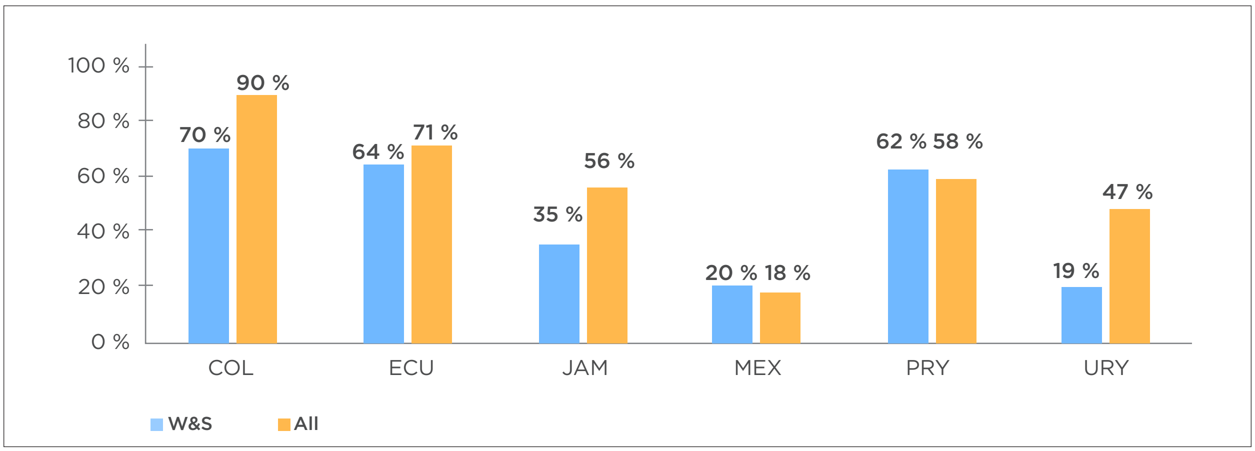


6. Comparative observations and policy recommendations

The analysis has contributed to the estimation of the costs of corruption in the W&S sector in Latin America and the Caribbean. Objective indicators and a transparent, replicable methodology have been used in order to analyze six case study countries, appreciating their specificities. Due to the differences in the underlying data and market conditions, the paper deliberately steered clear of ranking or comparing countries; nevertheless, the methodology followed the same logic across all countries. Among other factors, the methodology took into consideration that corruption in public procurement may vary in shape and form. Accordingly, the report developed a battery of different corruption risk indicators tailored to each country.

Due to the varying availability of data and the range of available variables in the six countries that were covered, the combination of corruption risk indicators is different from country to country, which means that comparing the different CRIs could be misleading. In addition, the underlying composition of contracts in the country datasets also differs (e.g. some have far fewer construction contracts). Nevertheless, it was possible to compare countries according to one widely available elementary risk indicator -- single bidding -- which has already been used in cross-country context in Europe (Fazekas & Kocsis, 2017). Figure 41 shows that while the contracting risks are significantly lower in the W&S sector compared to the whole public procurement sector in Colombia, Ecuador, Jamaica and Uruguay, the share of single bidding tenders in W&S is slightly above their national averages in Mexico and Paraguay. This finding points out the need for further analysis in these countries to help develop recommendations improving the governance of procurement processes in the W&S sector.

Figure 41: **Share of single bidder contracts in W&S sector vs. all contracts**



The diversity of datasets also reveals different W&S spending structures across the six countries. While one or two bigger organizations give the majority of contracts in Mexico, Paraguay and Uruguay, the W&S spending is more scattered across different organizations in the other countries. Moreover, some of the country datasets were predominantly derived from utilities, while in others, a great deal of contracts in the W&S sector could be identified that were not related to utilities.

This diversity of indicators, datasets, and regulatory frameworks provides the opportunity to identify a range of impacts in different contexts. Table 22 brings together the estimates for the different corruption impacts on prices and quality in the six countries, revealing that some effects are of modest magnitude, such as impact on delays, while others are major, such as impact on unit prices. Taken together and considering limitations of data and measurement, the analysis suggests that decisive policy reform focused on reducing risks by about two-thirds (aggressive scenario) could result in substantial savings across the sector: 7-16% of prices for standardized (e.g. chairs) as well as unique goods (e.g. pipes) and 10-19% lower incidence of cancellations and delays. While these savings may sound modest in percentage terms, given the high value of total spending in the sector, total savings from effective anticorruption reform are substantial. In addition, average savings figures mask different savings impact curves by country, hence different pay-offs to reducing corruption risks. In Uruguay and Mexico, the greatest price reduction can be achieved by targeting the upper end of the impact curve -- that is, the highest risk contracts. In Colombia and Paraguay, targeting the average-risk contracts appears to deliver greater benefits. Meanwhile, in Ecuador, there is no distinct domain of the impact curve that yields considerably larger benefits.

Table 22. **Summary of estimated corruption impacts, comparative findings**

Corruption impact	Corruption risk change scenario	Country basis	Impact range (relative improvement)
Prices: unit prices	Conservative	Mexico, Uruguay	0.8-1.3%
Prices: unit prices	Aggressive	Mexico, Uruguay	1.1-16.4%
Prices: relative prices	Conservative	Ecuador, Paraguay, (Jamaica)	1-1.9% (1.5%)
Prices: relative prices	Aggressive	Ecuador, Paraguay, (Jamaica)	2.5-7.3% (4.9%)
Delivery delay	Conservative	Colombia	6.1%
Delivery delay	Aggressive	Colombia	19.2%
Tender cancellation	Conservative	Colombia	1.1%
Tender cancellation	Aggressive	Colombia	9.8%

In spite of the extensive data mapping, collection, and standardization efforts and the use of replicable and widely lauded analytical methods, the study presents a number of limitations that future research should address. First, a number of data gaps should caution us about the validity of the findings. In each country, a large number of records was missing, with many known observations excluded from the analysis due to missing key variables such as prices. In addition, some of the crucial outcomes identified by our conceptual framework are missing. In particular, any information on cost overruns and broader measures of quality were missing, indicating that the extent of corruption could be underestimated, as prominent studies in the region revealed (Lagunes, 2017;

Campos et al, 2019). Second, while the strength of our approach is that it explicitly aims to pool different countries to get a more comprehensive picture of corruption impacts in the W&S sector, the large differences among countries in terms of regulations, data and structure of corruption limits comparability. Third, we cannot claim to draw conclusions directly representing relationships in the whole LAC region because the countries analyzed do not necessarily represent the full set of LAC countries. Fourth, a number of modelling choices was made that need to be further investigated to establish the robustness of findings. In particular, potential changes were expected in the results due to the magnitude of corruption risk reduction hypothesized, and the strength of relationship between CRI and dependent variables partially determined by the functional form assumed and controls included in the models.

Further research could build on the outlined approach, improving it and taking it further. The authors find it particularly important to further investigate the institutions and policies leading to corruption and to corruption costs in the W&S sector. In addition, linking the novel corruption proxies (red flags) to proven cases and administrative actions against corruption, such as audits or criminal investigations, could bring valuable benefits.

6.1 Policy Lessons

Despite these limitations, the following policy lessons can be offered and could form the basis of further policy discussions and reforms. Based on the data analysis conducted, we offer the following suggestions:

1

Improving public procurement data scope and quality

Public procurement data must be improved across the region if data analytics are to be more effectively used for guiding policy. In particular, data errors and missing fields should be decreased by better enforcing procurement regulations. In addition, the scope of national public procurement datasets could be extended to cover a wider range of impacts as well as corruption risk indicators:

- Indicators of prices -- both relative contract values (estimated versus awarded contract value) and unit prices (the latter is best deployed for standardized goods and services)
- Indicators of procurement results and delivery quality, such as information on project completion delays and cost overruns
- Indicators conducive to risk assessment, such as supplier country of registration, linked sanctions list (i.e. marking debarred companies), and losing bidders' names and bid prices

2

Introducing corruption risk assessment

Based on the available datasets and state-of-the-art corruption risk measurement methodologies, it is advised to develop risk assessment frameworks guiding both micro level decisions, such as audits, as well as policy reform, such as levels of oversight. Such frameworks could run on a near real-time basis and be made available through widely available and easy-to-use analytical dashboards. Oversight institutions such as supreme audit bodies or anticorruption agencies are well-placed to implement, operate and use such risk assessment. While acknowledging the specificities of the W&S sector governance in each country of the LAC region, the study suggests that water regulators should also embrace, adopt and apply risk assessment methodologies to support stronger oversight and control of activities related to water provision – starting with procurement - and ensure greater transparency in service.

3

Introducing public procurement cost monitoring

This study has shown that it is feasible and fruitful to estimate the impacts of corruption on prices and quality in public procurement. Given available public procurement datasets and the methodology introduced by this study, LAC governments, especially anticorruption agencies or supreme audit institutions, should regularly track the likely costs of corruption in order to inform investments into anticorruption activities from a cost-benefit perspective too.

4

Invest in public procurement reform to effectively lower corruption costs

Cost of corruption estimates, while arguably imprecise, allow for gauging some of the main public losses due to corruption in the W&S sector. These estimates suggest that investing in anti-corruption reform pays off already in a narrow cost-benefit sense while further contributing to less easily quantifiable benefits such as public trust in government. Anti-corruption agencies should incorporate the presented methodology into proactive sectoral monitoring (as opposed to waiting for corruption allegations to surface). This would support decision-makers in the W&S sector to weigh the risks generated by the lack of transparency in a particularly investment-intensive sector. Analysis of the impact of corruption on price and quality of public procurement should also be explored as a tool to re-focus anti-corruption strategies and allocate resources more efficiently, for example, by targeting risk profiles that promise the largest financial payoff.

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8. Appendices

8.1 Appendix A: Uruguay savings regressions

$$Log\ item\ unit\ price = \beta_0 + \beta_1 {*} CRI_{UY} + \beta_2 {*} CRI_{UY}^2 + \beta_3 {*} CRI_{UY}^3 + \beta 4 {*} Product\ code + \beta_5 {*} Contract\ award\ year + \beta_6 {*} Buyer\ type + \mathcal{E}$$

Table A1. Alternative regression specifications explaining relative prices, Uruguay, 2015-2018

	Log unit price			
	(1)	(2)	(3)	(4)
CRI(UY, 0-7 scale)	-0.0493	5.13***	4.994***	
	(0.821)	(0.000)	(0.000)	
CRI(UY, 0-7 scale) squared		0.17***	0.145	
		(0.000)	(0.285)	
CRI(UY, 0-7 scale) cubed			0.00158	
			(0.881)	
Categorical CRI (CRI(UY, 0-7 scale))				
Baseline: 0-1 red flags				
1-2 red flags				5.812***
				(0.000)
2-2.999 red flags				5.131***
				(0.000)
3-4 red flags				5.359***
				(0.000)
4-5 red flags				4.541***
				(0.000)
5-5.953 red flags				5.544***
				(0.000)
Controls				
Contract award year	Y	Y	Y	Y
Product code	Y	Y	Y	Y
Buyer type	Y	Y	Y	Y
Constant	Y	Y	Y	Y
Observations	4453	4453	4453	4453
R2	0.617	0.627	0.627	0.631

Note: * p < 0.10, ** p < 0.05, *** p < 0.01. Ordinary least squares regression results.
P-values in parentheses.

8.2 Appendix B: Mexico savings regressions

Log item unit price = $\beta_0 + \beta_1 * CRI_{MX} + \beta_2 * CRI_{MX}^2 + \beta_4$*Product code + β_5*Contract award year + β_6*Year quarter + β_7*Buyer type + β_8*Winner's legal form + β_9*Winner's sector + $\mathcal{E}$

Table B1. Alternative regression specifications explaining relative prices, Mexico, 2010-2018

	Log unit price			
	(1)	(2)	(3)	(4)
CRI(MX, 0-11 scale)	-0.298***	-1.021***	-1.894***	
	(0.000)	(0.000)	(0.000)	
CRI(MX, 0-11 scale) squared		0.161***	0.664***	
		(0.001)	(0.001)	
CRI(MX, 0-11 scale) cubed			-0.0697**	
			(0.007)	
Categorical CRI (CRI(MX, 0-11 scale))				
Baseline: 0-1.22 red flags				
1.23-3.14 red flags				-0.175
				(0.404)
3.14-4.12 red flags				-0.462
				(0.125)
4.13-4.88 red flags				-0.0877
				(0.868)
4.89-6.88 red flags				-0.713
				(0.312)
Controls				
Contract award year	Y	Y	Y	Y
Contract award year quarter	Y	Y	Y	Y
Winner's sector	Y	Y	Y	Y
Winner's legal form	Y	Y	Y	Y
Product code	Y	Y	Y	Y
Buyer type	Y	Y	Y	Y
Constant	Y	Y	Y	Y
Observations	1402	1402	1402	1402
R2	0.824	0.826	0.827	0.822

Note: * p < 0.10, ** p < 0.05, *** p < 0.01. Ordinary least squares regression results.

P-values in parentheses.

8.3 Appendix C: Colombia delay and cancellation regressions

Delay

Relative delay $= \beta_0 + \beta_1 * CRI_{COL} + \beta_2 * CRI_{COL}^2 + \beta_3 * Utility + \beta_4 * Buyer\ type + \beta_5 * Buyer\ location + \mathcal{E}$

Cancellation

Cancellation rate $= \beta_0 + \beta_1 * CRI_{COL} + \beta_2 * CRI_{COL}^2 + \beta_3 * Utility + \beta_4 * Buyer\ type + \beta_5 * Buyer\ location + \mathcal{E}$

Table C1. Alternative regression specifications explaining delays and cancellations, Colombia, 2011-2018

	Relative delay				Cancellation rate	
	(1)	(2)	(3)	(4)	(5)	(6)
CRI(COL, 0-8 scale)	0.0713***	1.374***	1.228***	0.0120***	2.099***	1.430***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
CRI(COL, 0-8 scale) squared		-0.250***	-0.184***	-0.00231***	-0.480***	-0.401***
		(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
CRI(COL, 0-8 scale) cubed			-0.00837			
			(0.211)			
CRI interacted with utility (Y/N)						
Baseline: CRI(COL, 0-8 scale) #utility=No						
CRI(COL, 0-8 scale) # utility=Yes				0.00465***		1.925***
				(0.000)		(0.000)
CRI(COL, 0-8 scale) squared #utility=Yes				-0.000332		-0.187***
				(0.173)		(0.000)
Utility (Y/N)						
Baseline: Utility=No						
Utility=Yes	-0.906***	-0.963***	-0.970***	-0.0175***	-2.120***	-5.278***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Controls						
Buyer type	Y	Y	Y	Y	Y	Y
Buyer location	Y	Y	Y	Y	Y	Y
Constant	Y	Y	Y	Y	Y	Y
Observations	34177	34177	34177	34177	33444	33444
R2	0.288	0.301	0.301	0.303	0.377	0.382

Note: * p < 0.10, ** p < 0.05, *** p < 0.01. Ordinary least squares regression results. P-values in parentheses.

8.4 Appendix D: Paraguay savings regressions

$$\textit{Relative price} = \beta_0 + \beta_1 * CRI_{PY} + \beta_2 * CRI_{PY}^2 + \beta_3 * CRI_{PY}^3 + \beta_4 * \textit{Contract award year} + \beta_5 * \textit{Contract sector} + \beta_6 * \textit{Log contract value} + \beta_7 * \textit{Buyer type} + \varepsilon$$

Table D1. Alternative regression specifications explaining relative prices, Paraguay, 2010-2018

	Relative price				
	(1)	(2)	(3)	(4)	(5)
CRI(PY, 0-9 scale)	0.0168***		0.151***		
	(0.000)		(0.000)		
CRI(PY, 0-9 scale) squared			-0.0346***		
			(0.000)		
CRI(PY, 0-9 scale) cubed			0.00262***		
			(0.000)		
Categorical CRI (CRI(PY, 0-9 scale))					
Baseline: 0-0.75 red flags					
0.75-2 red flags		0.165***			
		(0.000)			
2-4.5 red flags		0.206***			
		(0.000)			
4.5-9 red flags		0.216***			
		(0.000)			
CRI interacted with utility (Y/N)				Y	
CRI interacted with contract sector (Y/N)					Y
Controls					
Contract award year	Y	Y	Y	Y	Y
Contract sector	Y	Y	Y	Y	Y
Log contract value	Y	Y	Y	Y	Y
Buyer type	Y	Y	Y	Y	Y
Constant	Y	Y	Y	Y	Y
Observations	1293	1293	1293	1293	1293
R2	0.253	0.275	0.273	0.443	0.292

Note: * p < 0.10, ** p < 0.05, *** p < 0.01. Ordinary least squares regression results. P-values in parentheses.

8.5 Appendix E: Ecuador savings regressions

$$\textit{Relative price} = \beta_0 + \beta_1 {*} CRI_{ECU} + \beta_2 {*} CRI_{ECU}^2 + \beta 3 {*} CRI_{ECU}^3 + \beta_4 {*} \textit{Contract award year} + \beta_5 {*} \textit{Contract sector} + \beta_6 {*} \textit{Product type} + \beta_7 {*} \textit{Log contract value} + \beta_8 {*} \textit{Buyer type} + \beta_9 {*} \textit{Buyer location} + \varepsilon$$

Table E1. Alternative regression specifications explaining relative prices, Ecuador, 2013-2017

	Relative price			
	(1)	(2)	(3)	(4)
CRI(ECU, 0-7 scale)	0.0135***	0.0398***		
	(0.000)	(0.000)		
CRI(ECU, 0-7 scale) squared		-0.00891**		
		(0.001)		
CRI(ECU, 0-7 scale) cubed		0.000852**		
		(0.003)		
Categorical CRI (CRI(ECU, 0-7 scale))				
Baseline: CRI(ECU, 0-7 scale) quantile=1				
CRI(ECU, 0-7 scale) quantile=2			0.0225***	
			(0.000)	
CRI(ECU, 0-7 scale) quantile=3			0.00773**	
			(0.005)	
CRI(ECU, 0-7 scale) quantile=4			0.0237***	
			(0.000)	
CRI(ECU, 0-7 scale) quantile=5			0.0487***	
			(0.000)	
CRI interacted with contract sector				Y
Controls				
Contract award year	Y	Y	Y	Y
Contract sector	Y	Y	Y	Y
Product type	Y	Y	Y	Y
Log contract value	Y	Y	Y	Y
Buyer type	Y	Y	Y	Y
Buyer location	Y	Y	Y	Y
Constant	Y	Y	Y	Y
Observations	25454	25454	25454	25135
R2	0.242	0.242	0.241	0.247

Note: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$. Ordinary least squares regression results. P-values in parentheses.

8.6 Appendix F: Uruguay CRI regressions

$$logit(Single\ Bidder)_{UY} = \beta_0 + \beta_1{*}Political\ connection + (\beta_2{*}Decision\ p.1 + \beta_3{*}Decision\ p._2 + \beta_4{*}Decision\ p._{missing}) + (\beta_5{*}Submission\ p._1 + \beta_6{*}Submission\ p._2 + \beta_7{*}Submission\ p._{missing}) + \beta_8{*}Lack\ of\ call\ for\ tenders + (\beta_9{*}Procedure\ type_{weak} + \beta_{10}{*}Procedure\ type_{closed}) + \mathcal{E}$$

Table F1. Single bidder logit regression table, Uruguay, 2015-2018

	Single Bidder
Political connections	
Baseline: No political connections =0	0
	(.)
Political connections =1	-0.638***
	(0.000)
Decision period	
Baseline: Decision period = 29-42 days	0
	(.)
Decision period = 12-28 days	0.325***
	(0.000)
Decision period = 1-11 days	0.542***
	(0.000)
Decision period = missing	0.516***
	(0.000)
Submission period	
Baseline: Submission period = 73-183 days	0
	(.)
Submission period = 36-72 days	0.206***
	(0.000)
Submission period = 1-35 days	0.685***
	(0.000)
Submission period =missing	0.0165
	(0.776)

Lack of call for tender publication	
Baseline: Published call for tender=0	0
	(.)
Lack of call for tender publication=1	0.705***
	(0.000)
Procedure type	
Baseline: Open procedure type=0	0
	(.)
Weakly open procedure type=1	1.085***
	(0.000)
Closed procedure type=2	2.136***
	(0.000)
Controls	
Log contract value	Y
Buyer type	Y
Contract award year	Y
Winner type	Y
Contract sector	Y
Constant	Y
Observations	591663
R2	0.3147

8.7 Appendix G: Mexico CRI regressions

logit(Single Bidder)$_{MX}$ = $ß_0$ + $ß_1$*Published documents + ($ß_2$*Decision p.$_1$ + $ß_3$*Decision p.$_2$ + $ß_4$*Decision p.$_{missing}$) + ($ß_5$*Submission p.$_1$ + $ß_6$*Submission p.$_2$ + $ß_7$*Submission p.$_{missing}$) + $ß_8$*Contract modification$_{post}$ + $ß_9$*Contract modification$_{prior}$ + $ß_{10}$*Lack of call for tender + ($ß_{11}$*Procedure type$_{weak}$ + ß12*Procedure type$_{closed}$) + $\mathcal{E}$

Table G1. Single bidder logit regression table, Mexico, 2010-2018

	Single Bidder
Published documents	
Baseline: Number of documents=2-5	0
	(.)
Number of documents =0	-0.638***
	(0.000)
Decision period	
Baseline: Decision period = 9-365 days	0
	(.)
Decision period = 1-8 days	0.325***
	(0.000)
Decision period = 0 days	0.542***
	(0.000)
Decision period = missing	0.516***
	(0.000)
Submission period	
Baseline: Submission period = 15-181 days	0
	(.)
Submission period = 14-4 days	0.311***
	(0.000)
Submission period = 1-3 days	1.179***
	(0.000)
Submission period =missing	-0.504
	(0.723)

Contract modification during implementation	
Baseline: No contract modification	0
	(.)
Contract modification during implementation	-0.488**
	(0.005)
Contract modification during advertisement	
Baseline: No contract modification	0
	(.)
Modification before contract award	0.587***
	(0.000)
Modification after contract award	0
	(.)
Lack of call for tender publication	
Baseline: Published call for tender=0	0
	(.)
Lack of call for tender publication=1	2.483
	(0.080)
Procedure type	
Baseline: Open procedure type=0	0
	(.)
Weakly open procedure type=1	0.444***
	(0.000)
Closed procedure type=2	1.414***
	(0.000)
Controls	
Log contract value	Y
Buyer type	Y
Contract award year	Y
Contract award year quarter	Y
Product type	Y
Winner type	Y
Winner sector	Y
Constant	Y
Observations	48185
R2	0.2406

8.8 Appendix H: Colombia CRI regressions

$$logit(Single\ Bidder)_{COL} = \beta_0 + (\beta_1 * Decision\ p._1 + \beta_2 * Decision\ p._2 + \beta_3 * Decision\ p._{missing}) + (\beta_4 * Submission\ p._1 + \beta_5 * Submission\ p._2) + \beta_6 * Lack\ of\ call\ for\ tender + \beta_7 * Procedure_{typeclosed} + \mathcal{E}$$

Table H1. Single bidder logit regression table, Colombia, 2011-2018

	Single Bidder
Decision period	
Baseline: Decision period = 14-622 days	0
	(.)
Decision period = 0-2 days	1.178***
	(0.000)
Decision period = 3-14 days	0.578***
	(0.000)
Decision period = missing	5.012***
	(0.000)
Submission period	
Baseline: Submission period = >=7 days	0
	(.)
Submission period = 4-6 days	0.444***
	(0.000)
Submission period = 0-4 days	0.688***
	(0.000)
Lack of call for tender publication	
Baseline: Published call for tender=0	0
	(.)
Lack of call for tender publication=1	1.179***
	(0.000)
Procedure type	
Baseline: Open procedure type=0	0
	(.)
Closed procedure type=1	3.088***
	(0.000)
Controls	
Contract award year	Y
Product type	Y
Contract sector	Y
Buyer location	Y
Constant	Y
Observations	30492
R2	0.4533

8.9 Appendix I: Paraguay CRI regressions

$$logit(Single\ Bidder)_{PY} = \beta_0 + (\beta_1{*}Winning\ prob._1 + \beta_2{*}Winning\ prob._2 + \beta_3{*}Winning\ prob._{missing}) + (\beta_4{*}Description\ length_1 + \beta_5{*}Description\ length_2) + (\beta_6{*}Published\ documents_1 + \beta_7{*}Published\ documents_2) + (\beta_8{*}Decision\ p._1 + \beta_9{*}Decision\ p._2 + \beta_{10}{*}Decision\ p._{missing}) + (\beta_{11}{*}Submission\ p._1 + \beta_{12}{*}Submission\ p._2) + \beta_{13}{*}Lack\ of\ call\ for\ tenders + (\beta_{14}{*}Procedure\ type_{weak} + \beta_{15}{*}Procedure\ type_{closed}) + \mathcal{E}$$

Table I1. Single bidder logit regression table, Paraguay, 2010-2018

	Single Bidder
Winning probability	
Baseline: Winning probability =<33%	0
	(.)
Winning probability = 34-75%	0.736***
	(0.000)
Winning probability = 76-100%	1.782***
	(0.000)
Winning probability = missing	1.699***
	(0.000)
Tender description length	
Baseline: Number of characters =<39	0
	(.)
Number of characters = 40-515	0.0638*
	(0.010)
Number of characters >515	0.108***
	(0.000)
Number of related documents published	
Baseline: Number of documents >=19	0
	(.)
Number of documents = 14-18	0.440***
	(0.000)
Number of documents <14	0.739***
	(0.000)

Decision period	
Baseline: Decision period >= 65 days	0
	(.)
Decision period = 23-64 days	0.408***
	(0.000)
Decision period < 23 days	0.774***
	(0.000)
Decision period = missing	-0.210**
	(0.003)
Submission period	
Baseline: Submission period >= 48 days	0
	(.)
Submission period = 13-30 days	0.141*
	(0.024)
Submission period < 13 days OR 31-47 days	0.484***
	(0.000)
Submission period =missing	-0.000222
	(0.995)
Lack of call for tender publication	
Baseline: Published call for tender=0	0
	(.)
Lack of call for tender publication=1	4.030***
	(0.000)
Procedure type	
Baseline: Open procedure type=0	0
	(.)
Weakly open procedure type=1	0.690***
	(0.000)
Closed procedure type=2	0.921***
	(0.000)
Controls	
Log contract value	Y
Buyer type	Y
Contract award year	Y
Contract sector	Y
Constant	Y
Observations	114714
R2	0.4796

8.10 Appendix J: Ecuador CRI regressions

$$\text{logit(Single Bidder)}_{EC} = \beta_0 + \beta_1\text{*Same location} + (\beta_2\text{*Decision p.}_1 + \beta_3\text{*Decision p.}_{2.} + \beta_4\text{*Decision p.}_{missing}) + \beta_5\text{*Published call for tenders*Procedure type}_{weak} + \beta_6\text{*Published call for tender*Procedure typeclosed} + \beta_7\text{*Lack of call for tender*Procedure type}_{open} + (\beta_8\text{*Submission p.}_1 + \beta_9\text{*Submission p.}_2 - \beta_{10}\text{*Submission p}_{missing}) + \mathcal{E}$$

Table J1. Single bidder logit regression table, Ecuador, 2013-2017

	Single Bidder
Same location of buyer and supplier	
Baseline: Company not registered in same county as buyer =0	0
	(.)
Company registered in same county =1	0.155***
	(0.000)
Decision period	
Baseline: Decision period > 12 days	0
	(.)
Decision period = 8-11 days	-0.0880**
	(0.005)
Decision period < 7 days	0.0661**
	(0.004)
Decision period = missing	4.465***
	(0.000)
Lack of call for tender publication # Procedure type	
Baseline: Call for tender published # Catalogues	0
	(.)
Call for tender published # Open procedure type	0
	(.)
Call for tender published # Weakly open procedure type	-0.937***
	(0.000)
Call for tender published # Closed procedure type	-1.625***
	(0.000)
Lack of call for tender publication # Catalogues	0
	(.)
Lack of call for tender publication # Open procedure type	1.347***
	(0.000)
Lack of call for tender publication # Weakly open procedure type	0
	(.)
Lack of call for tender publication # Closed procedure type	0
	(.)

Submission period	
Baseline: Submission period = 26-65 days	0
	(.)
Submission period = 10-25 days	0.186***
	(0.000)
Submission period < 10 OR > 65 days	0.716***
	(0.000)
Submission period =missing	-3.100***
	(0.000)
Controls	
Log contract value	Y
Buyer type	Y
Contract award year	Y
Product type	Y
Contract sector	Y
Buyer location	Y
Constant	Y
Observations	591663
R2	0.3467

8.11 Appendix K: Jamaica CRI regressions

$$logit(Single\ Bidder)_{JM} = \beta_0 + (\beta_1 * Requested\ bids_1 + \beta_2 * Requested\ bids_2) + (\beta^3 * Procedure\ type_{weak} + \beta_4 * Procedure\ type_{closed} + \beta_5 * Procedure\ type_{govTogov} + \beta 6 * Procedure_{typemissing}) + \mathcal{E}$$

Table K1. Single bidder logit regression table, Jamaica, 2006-2018

	Single Bidder
Number of requested bids	
Baseline: Number of bids > 6	0
	(.)
Number of bids = 2-5	0.229***
	(0.000)
Number of bids = 0-1	2.03***
	(0.000)
Procedure type	
Baseline: Open procedure type=0	0
	(.)
Weakly open procedure type=1	1.58***
	(0.000)
Closed procedure type=2	6.54***
	(0.000)
Government to government=9	5.37***
	(0.000)
Procedure type =missing	3.407***
	(0.000)
Controls	
Log contract value	Y
Buyer type	Y
Contract award year	Y
Winner type	Y
Contract sector	Y
Constant	Y
Observations	138453
R2	0.6242

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