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Water and Sanitation Sector Integrity Risk Index

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ABSTRACT

We employ a data-driven approach to develop a composite Water Integrity Risk Index (WIRI) made up of a host of objective proxy indicators as well as survey-based measures of corruption experience to identify and assess integrity risks in the urban W&S sector in selected settlements around the world. Unlike broader-scope corruption indices, the WIRI outlined in this paper uses administrative datasets and survey data capturing information on corruptible transactions; thus, our analysis is micro-level, narrowly focuses on the W&S sector and is both transparent and replicable. The result is an actionable index which measures integrity risks over 7 countries between 2012 and 2019.

KEYWORDS

Corruption Risk Index, Water and Sanitation, Survey Data, Public Procurement

1 INTRODUCTION

Violations of integrity, fraud, and corruption result in reduced quality, affordability and availability of water and sanitation services. There is thus an urgent need to proactively and systematically identify, precisely and comprehensively measure, and effectively mitigate corruption risks in urban water and sanitation service provision.

The adverse effects of corruption and weak integrity on quality of life, state capacity, public services provision and economic output in the utilities sector have been widely addressed in scholarly literature (Atangana Ondoa, 2017; Chakraborty et al., 2014; Kirkpatrick et al., 2006; OECD, 2007). Acknowledging these unfavourable effects has led many international organisations and governments to call for effective action for strengthening integrity. However, policy reform effectiveness and adequate policy targeting are difficult to gauge without valid and reliable measurement of corruption.

This paper fills this gap by developing a novel measurement of integrity in the water and sanitation (W&S) sector in urban areas. It utilizes a data-driven approach to develop a composite Water Integrity Risk Index

(WIRI) made up of a host of objective proxy indicators as well as survey-based measures of corruption experience to identify and assess integrity risks in the urban W&S sector in selected settlements around the world.

The novelty of our approach comes from applying Big Data methods to administrative data and survey datasets in order to develop a comprehensive and actionable integrity risk indicator. To our knowledge, there is no integrity risk index for the W&S sector to date. Existing indexes focus on two aspects. The first is country-level reports of perception of corruption provided by sources such as the Political Risk Service, International Country Risk Guide and Transparency International's Global Corruption Index (Drury et al., 2009; Guasch & Straub, 2009). The second focuses on state-owned enterprises' transparency which is related to integrity but only partially overlaps with it. For example, Transparency International (TI) has developed indicators that measures the level of transparency of Public and State-Owned Enterprises based on the availability of free access to information. TI also evaluates and ranks companies based on indicators of the level of transparency of data per enterprise and the legal framework to make information available (Marek Chromý, Milan Eibl, Nemanja Nenadic, Zlatko Minic, 2019). Neither of these approaches focuses on direct and measurable corruption indicators specific to the W&S sector.

By contrast, as the WIRI outlined in this paper uses administrative datasets and survey data capturing information on corruptible transactions; our analysis is micro-level and narrowly focuses on the W&S sector. In addition, this analysis rests on open data sources, making our measurements both transparent and replicable.

The paper is structured as follows; first, we outline a focused review of the literature on integrity and corruption in order to identify relevant actors, transactions, data sources and forms of potential wrongdoings. Second, we provide a detailed description of the methodology and implementation in detail, as well as the criteria for selecting case studies and the resulting sample and datasets. Third, we calculate a host of elementary risk indicators and use a set of advanced data analytic methods for parametrising and validating each of them in order to define the building blocks for the composite WIRI and review its statistical properties both cross-sectionally and as a time-series.

1.1 Literature Review

The presence of corruption or lack of integrity is a phenomenon notoriously hard to measure, partially because its definition is subject to debate (Michael, 1996). Many definitions are so broad or vague that they are not suitable for guiding measurement. For example, the OECD defines public integrity as "the consistent alignment of, and adherence to shared ethical values, principles and norms for upholding and prioritising the public interest over private interests in the public sector" (OECD, 2017). Yet this demands a definition of what public interest is and what shared ethical values are. For any measurement exercise leading to actionable and comparable results, a clear benchmark needs to be set out.

In line with recent advances in conceptualising corruption and integrity, we define integrity as the open, fair, and impartial allocation of public resources to all citizens without favouring those with connections to the detriment to outsiders without such ties (e.g. family, friendship or bribery-based) (Mungiu-Pippidi, 2006; North et al., 2009; Rothstein & Teorell, 2008). This definition is not only conceptually sound, but it also resonates with everyday understandings of integrity and lack of corruption while supporting a coherent and tractable measurement framework as it will be shown below. In addition, this definition of integrity is closely matched by encompassing definitions of corruption, hence we use lack of integrity and corruption interchangeably.

We expect that corruption and integrity in the W&S take on *sui generis* dynamics. This sector is best defined as the infrastructure and services related to providing safe and quality drinking water and sanitation services (Baillat, 2013; Das et al., 2016). Corrupt acts in the W&S are those which violate the obligation to protect the human right to water (Baillat, 2013). These acts lead to arbitrary or unjustified disconnection or exclusion from water services or facilities and discriminatory or unaffordable increases in the price of water (Auriol & Blanc, 2009). Moreover, corrupt exchanges in the value chain of water utilities (inputs) also affect access to water connections and sanitation services (outputs).

Given the different sets of public and private actors[i] in the W&S sector (Jergelind, 2015), corruption can take various forms depending on the underlying interactions and structures. Hence, we define two levels or types of corrupt violations of integrity: grand corruption and petty corruption. First, grand corruption in the sector is defined as bribes, kickbacks, or any other favour received by politicians, civil servants or utility leadership to give undue support or to award contracts to selected consultancy firms, constructing firms, and additional water and other sanitation-related companies (Hall & Lobina, 2007). Second, petty corruption in the W&S sector involves cash bribes from customers to low or middle-level civil servants to facilitate or speed the delivery of W&S services (Rafi et al., 2012).

Based on the above, our framework focuses on 3 main pillars of integrity in the W&S sector:

1. Public investment projects (e.g. building new pipelines or drainage),
2. Recurrent spending supporting ongoing operations (e.g. paying salaries, purchasing computers), which is addressed as operations in this work; and
3. Client-utility interactions (e.g. paying utility bills).

1.1.1 Pillar I: Investment Integrity

Corruption in investment projects in the W&S sector typically ends up happening through public procurement or government contracting. In public procurement, the aim of institutionalised corruption is to steer the contract to the favoured bidder without detection in a recurrent and organised fashion (Fazekas & Tóth, 2014; World Bank, 2009). Corruption in public procurement requires at least two violations of principles of fair distribution of public resources: 1) avoiding competition, by for example using unjustified sole-sourcing or direct contract awards; and 2) favouring a particular bidder, by for instance tailoring specifications, or sharing inside information. This definition of corruption focuses attention on restricted access to and unfair competition for public resources (Mungiu-Pippidi, 2014; North et al., 2009).

Often times, contractors compete against each other by partnering with elected officials and senior bureaucrats who can provide insider information and/or carefully manipulate tender documents to subvert competition (Davis, 2004). Even when there is some form of competitive bidding, bidders often form cartels to set prices and who wins which contract (Davis, 2004). Furthermore, corrupt companies continue to increase their profit margins by colluding with the technical staff during the contract implementation phase (Davis, 2004). The technical staff are motivated to ensure continuation of these relationships in order to secure a steady flow of bribes, and also have interest in construction works to proceed as planned as that would secure a steady flow of bribes linked to milestones and deliveries. Nevertheless, falsification of deliveries also widely occurs in many contexts.

Corrupt acts which influence contracts or bids result in fraud to over or underestimate assets; selection and type, award of concessions; decisions over duration, exclusivity, tariffs, subsidies, this impacts the quality of the work and the time it is completed. Additionally, fraud in invoicing may be present through marked-up pricing, and or overbilling by suppliers. This may result in not building to specification, concealing substandard work or the failure to complete works or in the management of the service (OECD, 2007).

1.1.2 Pillar II: Operations Integrity

Once the utility is operating, integrity may be lacking throughout the maintenance of the service and the execution of its budget (Plummer & Cross, 2007). This can manifest itself as administrative corruption in personnel management when presents and payments are made by candidates to receive appointment, promotion, or conserve strategic post (e.g. utility directorships). Also, the inflated cost of the service facilitates nepotism in the hiring of technical staff (Pusok, 2016) who aim to conserve their posts in order to continue asking for bribes from the same group of people (Punjabi, 2017). These power relations allow a particular group of people to gain and maintain control of the service while continuing to undermine integrity.

In addition to nepotism, corruption in operations can take further forms. For example, senior agency administrators may ask for a payment from professional and engineering staff in exchange for favourable reviews, promotions, and transfers (Punjabi, 2017). Ghost employees on the payroll may be present (Levy, 2007) this is a practice used to pay back favours between actors. These practices lead to inadequate recruitment of staff which impacts operations. Additionally, inflated costs for the maintenance of the service relating to chemicals, vehicles or equipment are also present throughout the W&S sector (OECD, 2017).

1.1.3 Pillar III: Interactions Integrity

Lack of integrity in the client-utility nexus can take a variety of forms with different effects such as unaccounted for water, unofficial usage of tankers, low reporting of faults, unexplained zonal variations, and ignored complaints from consumers and small scale providers (Gulati & R a o, 2007). Each of these outcomes of low-level corruption typically results from bribes paid by the client, private household or company, to low-level bureaucrats of the utility company. Nevertheless, mid to high ranking officials in the utility company may also support or even facilitate such a scheme in order to further extract rents for themselves or simply to keep under-paid bureaucrats at bay.

Payments are made in exchange for several services, such as expediting applications for new connections; quick attention to water supply works and sewer repair work; the falsification of water bills; and ignoring illegal service connections. Industrial actors, with regards to connection of electricity and water after submitting applications, admit that bribes are required at every stage of the process (Makoni, 2014). This also impacts on a range of businesses processes as industrial actors require water to produce goods or in order to provide their services (Makoni, 2014).

2 METHODOLOGY

The Water Integrity Risk Index (WIRI) uses administrative datasets and survey data in order to develop a comprehensive and actionable composite index which is comparable across different organisations and over time. We identify three pillars of integrity in three areas where wrongdoing can happen: a) investment, b) operations, and c) client-utility interactions. Each of the three pillars can be assessed using a host of tried corruption and integrity indicators based on both administrative and survey data sources, resulting in a robust and comprehensive measurement.

Given that integrity is a latent variable, we must rely on proxy indicators which can, in conjunction, reveal integrity risks. The most widely used methods for latent variable estimation are principal-component analysis and structural equation modelling (Dillon et al., 1996; Hoyle, 2012; Pituch, 2015). These are widely tested and suitable methods for our purposes; however, given the small sample size and large number of missing values in our dataset, we opt for a simpler approach by generating the composite WIRI in the following steps:

1. We standardize each component indicator of integrity-risk so that they can be directly compared (higher values imply higher integrity).

2. Calculate the weight of each component indicator (5 in total, categorized into 3 pillars) by the amount of data points available for the timeseries (2012-2019). Fewer available data points in a component lead to a decrease its pillar weight on the index.

3. We calculate the weighted mean of each indicator (see table 3) to derive the composite WIRI score based on the data available.

2.2 Data sources and sampling

In order to identify suitable datasets and indicators, we carried out a comprehensive search strategy starting from as broad a list of countries as possible then subsequently narrowing down the list to countries and settlements where multiple datasets and integrity indicators intersect. The search strategy focused on open sources which provide valid measures of integrity and offer a consistent dataset across time, covering the 2005-2019 period. We mapped available data sources and relevant indicators, in particular: their location and accessibility, exact definition, targeted geographical unit, time-period covered, and sector-of-measurement. Where it was needed, we requested micro-data on top of publicly available aggregates. The mapping concentrated 4 distinct types of data:

1. Surveys of corruption experiences,
2. Public procurement data, including risk indicators,
3. W&S utility data,
4. National Statistical Office data.

Given budgetary constraints, we opted for a shortlist of 7 countries where the data collection and analysis exercise would be carried out. The shortlist of countries and their settlements was identified based on the scope, quality, and availability of data per year in all relevant datasets. In addition, our aim was to ensure geographic diversity in the sample of countries.

Once the country sample was identified, we selected large and mid-sized urban settlements and capital cities. Thus, we included the capital city as a pilot settlement for each of the pilot countries and added further settlements in all the countries where data permitted. Each of the settlements is assigned a code according to alphabetical order. The shortlisted settlements are:

1. Asunción/Gran Asunción - Paraguay -
2. Batumi - Georgia
3. Bucharest – Romania
4. Budapest – Hungary
5. Cluj - Romania
6. Győr - Hungary
7. Iasi - Romania
8. Kampala - Uganda
9. Montevideo - Uruguay
10. Nairobi - Kenya
11. Nyíregyháza - Hungary
12. Tibisili - Georgia

Though we attempted to select settlements with a comprehensive data coverage, even this shortlist included several settlements where not all identified data sources were available for every year. For example, in most cases, the survey of corruption experiences was run 2 or 3 times in the last 10 years. We report the sparsity of data points between 2012 and 2019 in Table 1. The table summarises the component indicators (described in section 2.3), the missing data points for each indicator in a balanced panel dataset (settlements and years), the rate of data availability and the calculated weight for each component based on the former.

Table 1. Data sparsity per integrity indicator (2012-2019)

Variable	Pillar	Missing Data	Available Data Rate
PP Investment Integrity Risk	Investment Risk	10	90%
Infrastructure Investment Risk	Investment Risk	63	34%
PP Operations Integrity Risk	Operations Risk	11	88%
PP Client Utility Interaction Risk	Client-Utility Interaction Risk	58	40%
Survey Data Integrity	Client-Utility Interaction Risk	92	4%

2.3 Indicators

In this section, we define each indicator and asses its strengths and weaknesses, as well as the additional indicators which would further enhance the reliability and validity of the index in subsequent iterations. First, we present public procurement indicators which are used in all 3 pillars and then we discuss the specific indicators for each pillar in turn.

Public procurement risk indicators – which are present in the three different pillars (Investment Risk, Operations Risk, and Client-Utility Interaction Risk) – capture the risk of deliberate restrictions to open and fair competition in public tenders and contracting decisions in order to benefit a connected bidder (Fazekas & Kocsis, 2020).[ii] We assign each public procurement contract to one of the 3 pillars using product codes specific to the nature of W&S activity defined by public procurement data systems such as the Common Procurement Vocabulary (CPV) codes and the United Nations Standard Products and Services Code (UNSPSC). The data is collected using countries' national public procurement portals, thus there is always a risk of biased or invalid information being fed to those portals. However, we undergo validity checks to make sure the data is consistent to maximize reliability.

The public procurement risk indicator is a composite score of five elementary risk indicators (see Table 2): the length of the decision period, the procedure type, single bidder contract, the length of the advertisement of the contract and call for tenders' publication. For ease of interpretation, we average over these 5 indicators to arrive at a composite score and use the same score calculation methodology in each of the three pillars. The composite score is scaled so that it falls between 0 and 100, with 100 representing the highest integrity and 0 representing the lowest integrity (lack of integrity). We construct weights which utilise number of contracts in order to account the differences between settlements in accordance to amount of micro-interactions.

Table 2. Public Procurement Risk Indicator definitions

INDICATOR NAME	INDICATOR DEFINITION
LENGTH OF DECISION PERIOD	100=length of decision period is unrelated to corruption risks (single bidding) 0=length of decision period OR missing decision period is related to corruption risks (single bidding)
PROCEDURE TYPE	100=open 0=non-open (accelerated, restricted, award without publication, negotiated, tender without competition)
SINGLE BIDDER CONTRACT	100=more than 1 bid received 0=1 bid received
CALL FOR TENDERS PUBLICATION	100=call for tender published in official journal 0=NO call for tender published in official journal
LENGTH OF ADVERTISEMENT PERIOD	100=length of advertisement period is unrelated to corruption risks (single bidding) 0=length of advertisement period or missing advertisement period is related to corruption risks (single bidding)

The procurement-based indicators and survey data are then utilized to calculate pillar-level indictors, and subsequently to calculate the WIRI score. The first pillar, Investment Integrity Risk (IIR), estimates integrity risks in investment projects, it incorporates public procurement risk indicators and a pipe length-based indicator from national statistical offices. Following existing literature (Klašnja, 2017), we posit that large investments into piping infrastructure without a corresponding increase in pipe length is of concern, thus a risk factor. We incorporate this risk indicator of missing infrastructure by comparing the total length of the network with prior investment. In a regression set-up, this indicator is defined as the error term of the panel regression regressing the change in the stock of pipe length on the current and last year's infrastructure investment value while controlling for baseline pipe network length. Pipe length is measured as the length of the total network in a settlement in km provided by statistical offices in a yearly and consistent manner. In order to account for pipe investment in the model we select different pipe investment related categories from the selected W&S tenders, some examples include "irrigation, pipe construction work, bends, pipelines". We observe the missing infrastructure indicated by lower values of the residuals from the regression model which are normalized between 0 and 100.

The Operations Integrity Risk (OIR) indicator considers the lack of integrity throughout the maintenance and operations of the service provided by the utility (Plummer & Cross, 2007). The OIR utilises the public procurement risk indicators from maintenance, as categorized by CPV and UNSPSC codes. Examples of these include chemicals products, transportation equipment, laboratory materials, IT services. This indicator is consistent and reliable thought different years. However, it is important to clarify that the OIR indicator does not incorporate the total salary of the staff in the Utility or manipulation of hiring and promotion which can result in lack of integrity (Punjabi, 2017).

The third pillar corresponding to the Client Utility Interaction Integrity Risk (UIR) indicator includes two metrics: a) the public procurement risk indicator and b) an indicator which integrates direct experience with corruption represented as admission of bribery by households towards the W&S service (Rafi et al., 2012, Punjabi, 2017).[iii] We construct the client utility interaction integrity risk component from the public procurement risk indicator using the water utility as a supplier in the public procurement process.

We employ survey data from two sources to construct the indicator on bribery experiences in the W&S sector (Davis, 2004; Makoni, 2014). From the Global Corruption Barometer, we obtain admissions of bribery in the W&S sector for 2016. The second survey selected is the Afro-barometer. Once again, we collect positive responses from a representative sample of the population of settlements in Africa who admit to bribing to obtain water services. However, individuals in surveys do not always openly disclose participating in bribery (Davis, 2004); this may result in low admission rates in settlements. For each of the available surveys, we calculate the rate of bribery by dividing the number of respondents who admitted bribery over the total number of respondents who required or requested a W&S service in a settlement.

The two surveys include admissions of bribery towards public officials, though fail to include customer bribes to falsify meter readings, the existence of illegal connections, or speed money to expedite repairs (Punjabi, 2017). To our knowledge, there is no survey that investigates these issues in a consistent, reliable and valid manner across countries. Given these limitations, the survey component of the WIRI index has the lowest weight (1.6%). It is important to note, however, that as survey data becomes more systematically available, the relative weight of this component could be scaled upwards in subsequent iterations (see Table 1).

Finally, we integrate control variables to account for the differences between settlements and the public procurement indicators, making these units relatable in context. For public procurement risk indicators, we include total number of contracts as frequency weights in the W&S sector. Equally, for the client utility interaction survey indicators we utilise the total number of respondents that required a service or a new connection as the frequency weight for the sample. In order to provide a comparable measure, the total value of is contracts represented in International USD (GK$).[iv]

3 RESULTS

We present the WIRI index data per settlement as both cross-section and time-series. Given the availability of surveys and investment indicators we selected an 8-year period (2012 to 2019) for both the cross-sectional and time-series analysis.

The cross-sectional composite WIRI is created based on information on all 3 pillars. For the investment risk pillar, we average over integrity risks in public procurement tenders as well as missing pipe stock. For the operations risk pillar, we could only make use of public procurement-based indicators. And for the client-utility interactions we combined public procurement-based risk scores with survey-based metrics.

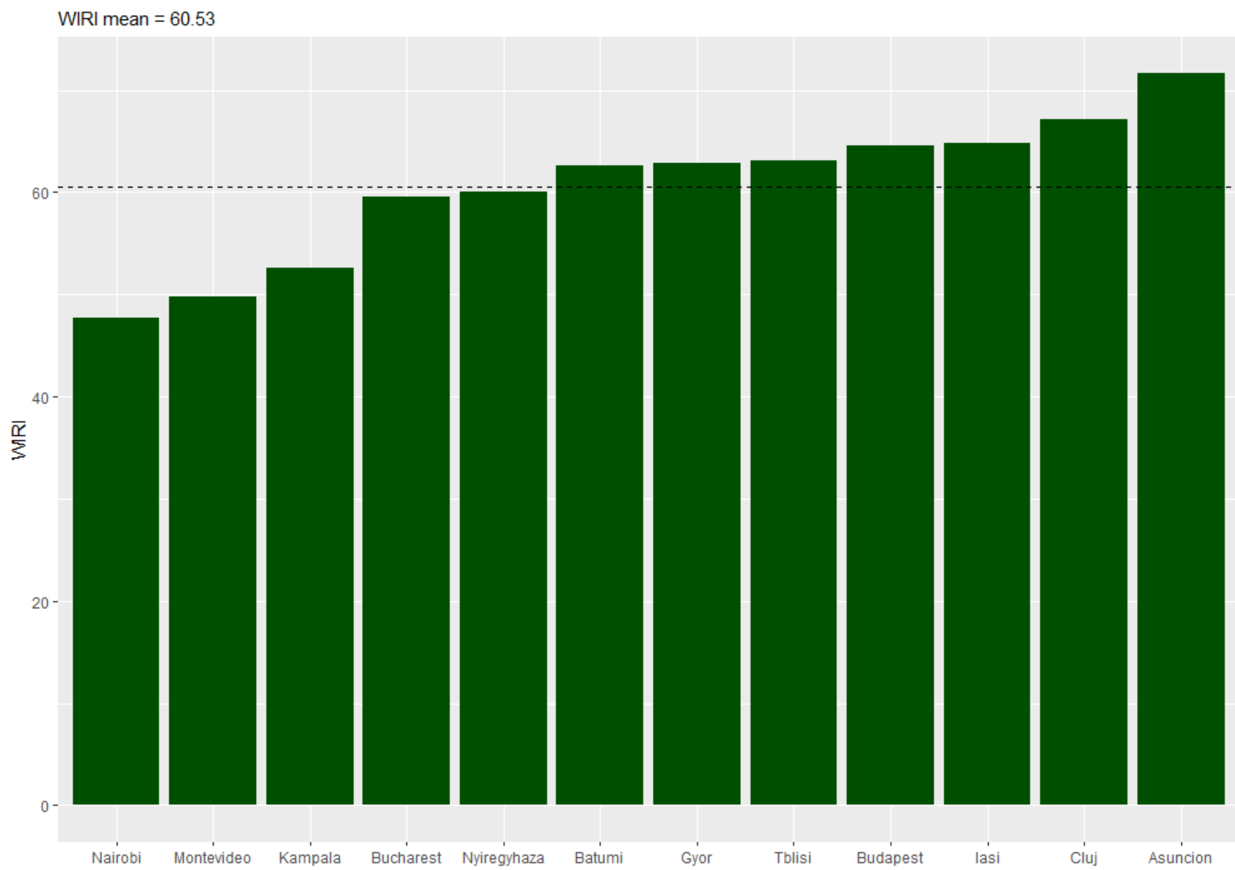
Based on the three pillars discussed in the previous sections, we calculate the weighted average per settlement (see Table **3**), where the weight of the pillars is directly proportional to the ratio of available data for each. The global pillar weights and indicator averages per settlement are summarised in Table 3.

Table 3: Composite Water Integrity Risk per settlement (2012-2019)

Pillar	**Investment Risk**		**Operations Risk**	**Client-Utility Interactions Risk**		**Composite Index**			
Weights	**.35**	**.13**	**.35**	**.15**	**.02**	**48%**	**35%**	**17%**	**100%**
Settlement	*PP Investment Integrity Risk*	*Infrastructure Investment Risk*	*PP Operations Integrity Risk*	*PP Client Utility Interaction Risk*	*Survey Data Integrity*	**WIRI INV**	**WIRI OP**	**WIRI CUI**	**WIRI**
Asuncion	74.96	NA	71.70	NA	1.97	74.96	71.70	61.97	71.62
Batumi	65.69	NA	59.81	59.50	NA	65.69	59.81	59.50	62.60
Bucharest	67.85	31.57	81.51	43.33	NA	49.71	81.51	43.33	59.61
Budapest	75.17	25.72	77.95	77.31	NA	50.45	77.95	77.31	64.54
Cluj	72.35	34.96	86.09	NA	NA	53.66	86.09	NA	67.17
Gyor	71.40	25.97	76.69	75.00	NA	48.68	76.69	75.00	62.85
Iasi	73.43	31.25	82.25	NA	NA	52.34	82.25	NA	64.80
Kampala	52.82	NA	53.06	51.16	NA	52.82	53.06	51.16	52.62
Montevideo	41.33	NA	42.18	NA	9.02	41.33	42.18	89.02	49.76
Nairobi	44.98	NA	38.16	NA	4.81	44.98	38.16	74.81	47.72
Nyiregyhaza	68.80	27.81	69.42	74.09	**NA**	48.30	69.42	74.09	60.00
Tblisi	66.30	NA	65.08	50.00	**NA**	66.30	65.08	50.00	63.09

Figure 1 ranks each settlement by its WIRI score. As shown in the table above, certain cases do not contain the client utility interaction risk indicator because the interactions are low and do not allow robustness in the data.

Figure 1: WIRI ranking of settlements (cross-sectional)



The 3 pillars are however not equally strongly associated with the composite WIRI score. The investment and operations pillars have a strong positive relationship with WIRI (Figures 2 and 3). However, we find weak *negative* correlation between WIRI and the client-utility interactions (Figure 4). It may well be that this discrepancy is due to the generally weaker empirical basis for the client-utility interactions pillar, but it can also mean that high-level corruption and low-level bribery are largely disconnected from each other.

Figure 2: Scatterplot of WIRI and WIRI investment pillar scores (cross-sectional)

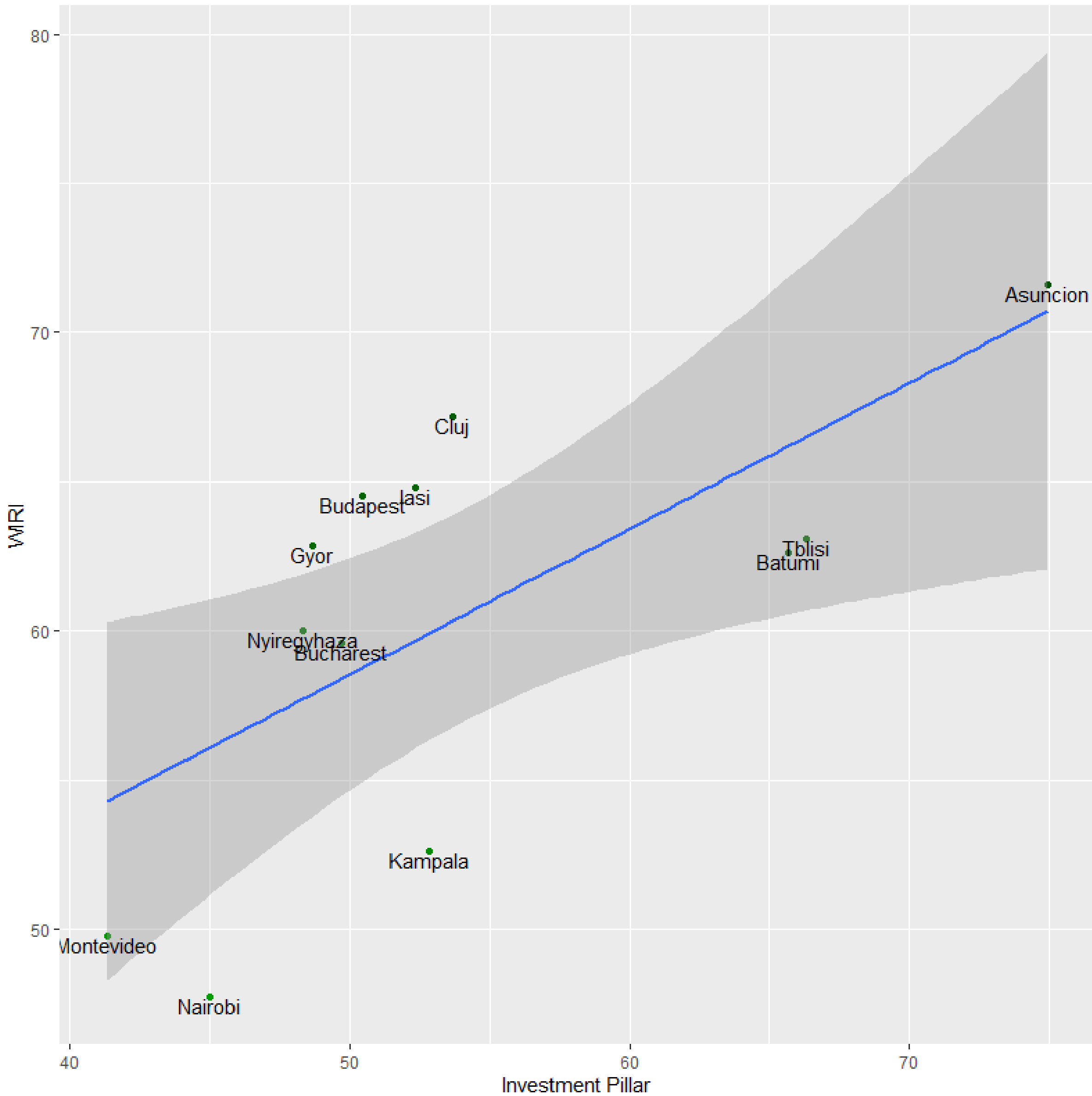


Figure 3: Scatterplot of WIRI and WIRI operations pillar scores (cross-sectional)

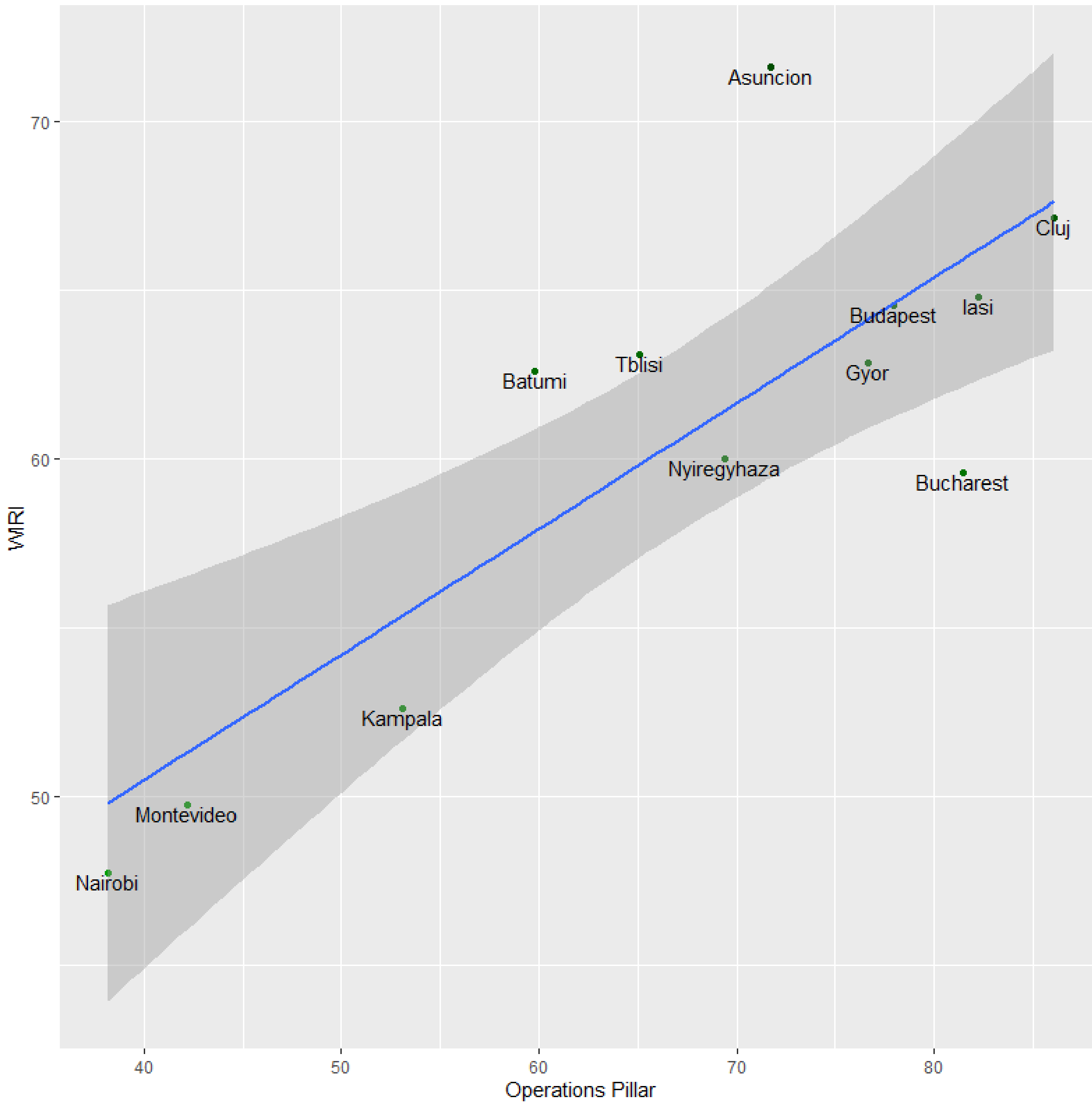
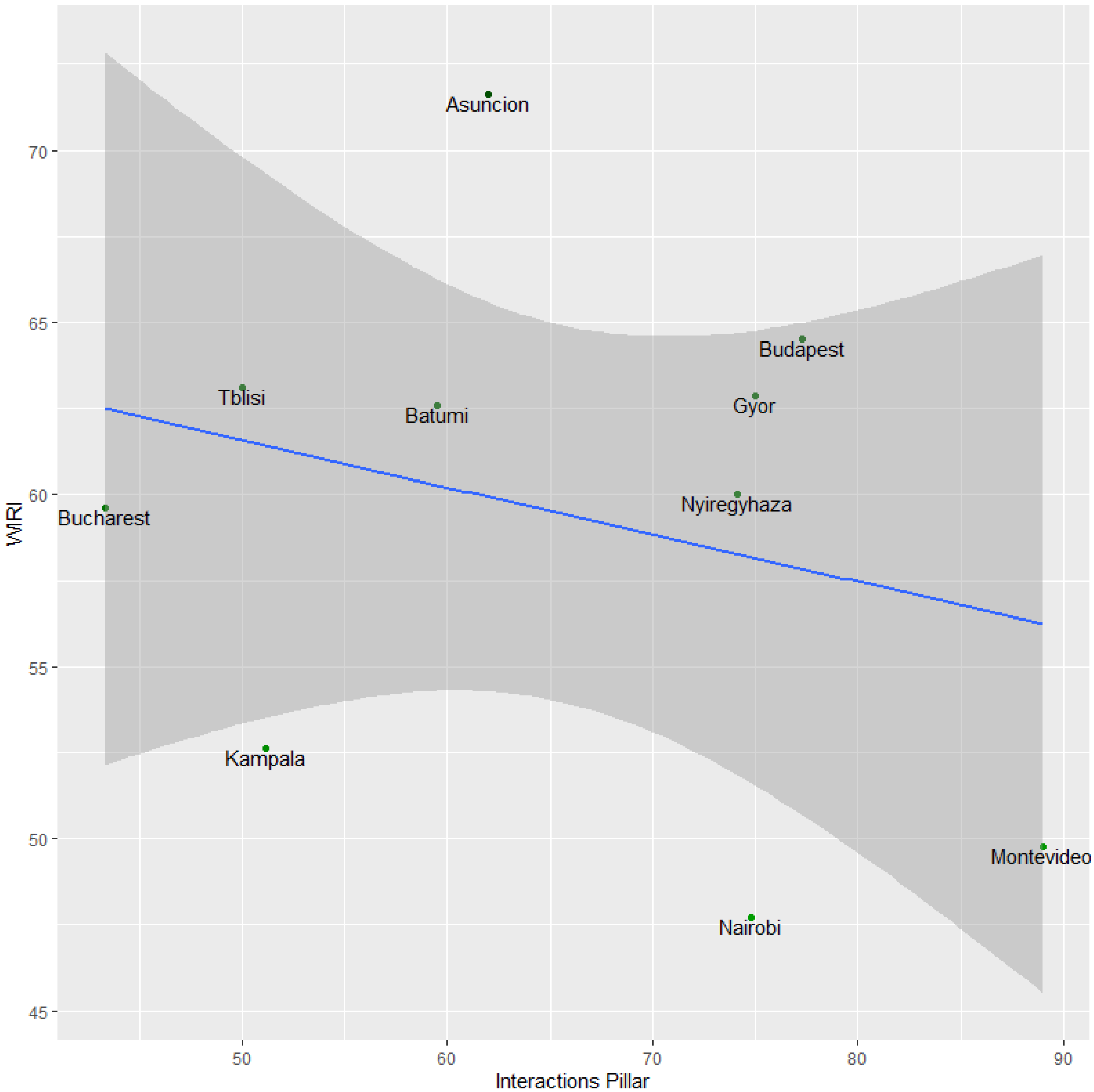
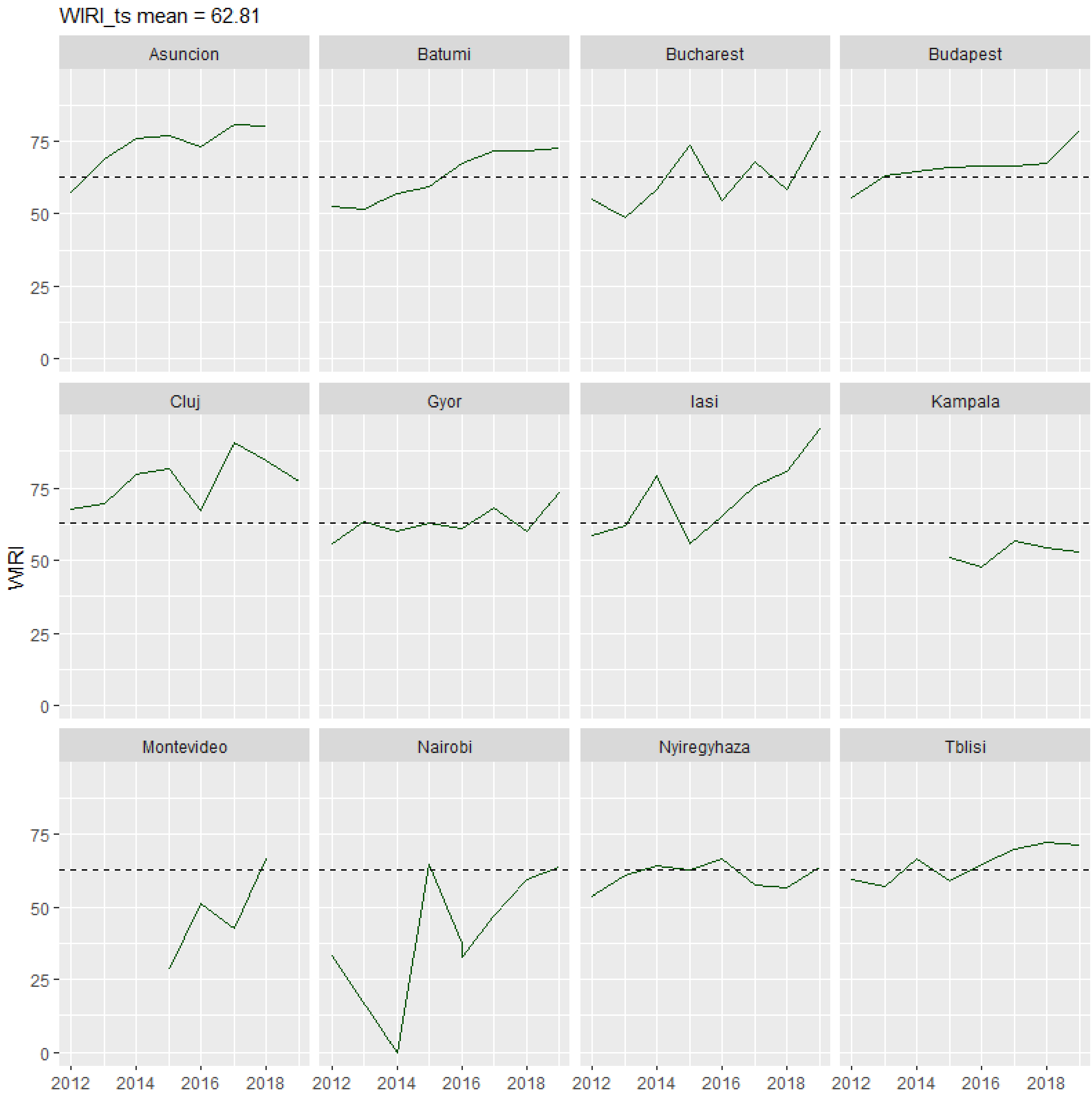


Figure 4: Scatterplot of WIRI and WIRI interactions pillar scores (cross-sectional)



Next, we present the dynamics of the WIRI index over time. Figure 5 shows the evolution of WIRI scores per settlement whenever we had sufficient data (at least 5 contracts per year per pillar). There is an improving trend in part of the sample, for example in Asuncion, Batumi, Iasi and Nairobi. Whereas in other settlements, we see stagnation, and in the case of Nyiregyhaza we observe soft decline in the index score.

Figure 5: Longitudinal WIRI by settlement (2012-2019)



Conclusions

The Water Integrity Risk Index presented in this paper aims to provide an objective measure of corruption risks in the urban water and sanitation sector. As shown in the preceding sections, WIRI is a replicable, transparent and scalable index, which enables us to compare risk levels in the sector across time and between cities. Moreover, using WIRI we can also observe variations in the three pillars, and retrieve detailed information about individual indicators that increase or reduce the overall rating of the index. These attributes of WIRI makes it a potentially useful measurement for all stakeholders, especially policy makers in the W&S sector.

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Endnotes

[i] These actors are defined based on the regulatory and organisational context of local water utilities as well as detailed qualitative research (Davis, 2004).

[ii] Fazekas & Kocsis (2020) define the Corruption Risk Index (CRI) which denotes higher values as high corruption. We build on their work but reverse the scale to match the integrity logic of the WIRI.

[iii] Though the index would be strengthened by combining the perspectives of corruption in the W&S sector from both households and businesses, surveys on the latter have not yielded data suitable for our purposes. An example of this is the World Bank Business Enterprise Service Modules Survey (BEEPS), which collects admissions of bribery for water and sanitation services by member of the business community. Though geolocated and topical, the number of respondents per settlement per year is very low (under 20) which is why we exclude it from this iteration.

[iv] Our calculation uses purchasing power parity ratio provided by the World Bank which is a standard measure of price level differences across countries in consumption in local currency after inflation.