

The Dividends of Digitalization and Big Data to Institutional Quality and the Macroeconomy

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ABSTRACT

This chapter analyzes interactions between digitalization and big data innovations and institutional quality, and how these interactions influence economic outcomes. It discusses the increasingly important role of e-government in the provision of online public services, the importance of expanding the existing telecommunication infrastructure, and the necessity of enhancing the ability of populations to use e-government services (the “human capital” dimension). The empirical analysis uses data from 132 countries and confirms the potential of these innovations to improve government effectiveness and to reduce corruption through transparency, checks on government officials’ discretionary powers, accurate policymaking, and trust in government. Good sequencing of these innovations can maximize their potential to strengthen government effectiveness. The chapter provides preliminary indications that e-government can boost government revenue mobilization through lower corruption and enhance public spending effectiveness, especially during crises.

INTRODUCTION AND CONTEXT

Many governments are harnessing digitalization and big data analytics,¹ boosted by the acceleration in the use of electronic devices and the ensuing densification of social networks. They aim to leverage these innovations to improve the living conditions of their populations, including through the impact of the innovations on the quality of public institutions—the rules of the game in a society (North 1990). Indeed, economists concur about the positive relationship between the quality of institutions and macroeconomic outcomes (Acemoglu and others 2002; Djankov and others 2003; Glaeser and others 2004). Some estimates put

¹ “Big data” refers to the large volume of data now available, its variety, and the speed at which it can be processed. “Analytics” is the means for extracting value in the form of actionable insights from this data (EY Americas 2019).

the cost of corruption, a key indicator of the quality of institutions, at more than 5 percent of world GDP (World Economic Forum 2020). Estimates in Chapter 1 and Chapter 2 suggest that bringing sub-Saharan Africa's institutional quality to the world average would increase annual GDP per capita growth by 1–2 percentage points. Studies have also shown a positive relationship between institutional quality and the adoption of digitalization and data analytics in government operations (for example, CEBR 2016; Krishnan, Teo, and Lim 2013). The causality between these variables and the direction of the causality are, however, a matter for debate, which is relevant to the sequencing of reforms. Further, the literature has devoted little attention to the extent to which the innovation content of change in institutional quality affects macroeconomic outcomes. Experience suggests that e-government² supports good governance and is essential for effective, accountable, and inclusive institutions (Haldenwang 2004). Available estimates of annual savings from the use of big data analytics range from \$20 to \$41 billion for the United Kingdom and \$223 to \$446 billion for the European Union (World Bank 2017). These studies base their figures on efficiency gains, reduced fraud and error, and improved tax collection, all of which reflect institutional quality changes supposedly caused by e-government innovations. Thus, e-government endows governments with better information and analytical capabilities to improve the accuracy of their policymaking and the effectiveness of their policies; it also reduces corruption by enhancing transparency and limiting executive power's discretion (Bruinshoofd 2016). Recently, amid the COVID-19 pandemic, many countries used big data and information and communication technologies (ICT) to save lives and protect livelihoods (Wu and others 2020). As discussed in Chapter 12, real-time audits of emergency spending enabled by these innovations can curb corruption and save resources, and thus contribute to fighting the COVID-19 pandemic, as they did during the 2014 West Africa Ebola outbreak.

Reducing the knowledge problem³ through more systematic use of data for decision-making enhances government effectiveness and institutional quality, but trust in government, participation, and compliance with rules and regulations—critical to institutions' sound functioning—require transparency. Indeed, institutional transparency is the basis of sound economic governance and arguably the first step in improving accountability and integrity. Digitizing public services and increasing government's use and publication of data can help achieve transparency. Countries with better institutions, ones that embrace transparency and accountability, would thus be more inclined to adopt integrity-friendly innovations despite the reduction in the government powers such innovations entail. Following

² The term “e-government” was introduced to describe the use of ICT and big data innovations to promote citizen empowerment, improve service delivery, strengthen accountability, increase transparency, or improve government efficiency (European Union, n.d.; World Bank 2015).

³ The knowledge problem highlights the paradox of not having the knowledge to make a decision but pretending to have it and act. Such an approach calls into question the legitimacy of governmental decision-making and its impact on the economy (Erkut 2020).

this line of reasoning, good institutions are a precondition for e-government, including data-based public policymaking processes.

This chapter offers an overview of digitalization and big data analytics innovations and how their interplay with the quality of institutions influences macroeconomic outcomes. Following the two initial schools of thought of the new institutional economics (NIEs),⁴ the chapter assumes that institutional quality encompasses firm-level property rights and contracts and the broader institutional environment.⁵ After a structured analysis of recent developments in institutional quality and e-government, the chapter examines their relationship. It then discusses how this relationship affects revenue and spending, two key variables for macroeconomic stability.⁶ The results presented in the chapter should be interpreted with caution, given the limited data available and the limitations of the econometric techniques used. These techniques cannot fully address methodological challenges such as reverse causality, endogeneity, and omitted variables. The analysis is, however, helpful in charting new directions for research.

ICT, DATA INNOVATIONS, AND INSTITUTIONAL QUALITY

In its October 2020 report, the International Telecommunication Union (ITU 2020) estimated that 60 percent of the world's population is connected to the internet. However, the patterns of internet usage vary widely by age, location, and income, and during good and bad times. First, young people tend to use the internet more than their older peers. Almost 70 percent of young people aged 15 to 24 use the internet, while the average across all age groups is just over 50 percent. Second, sub-Saharan Africa lags all other regions, with only 29 percent of its population using the internet, compared to 83 percent in Europe at the other end of the spectrum. Third, skills and education levels continue to explain the persistence of gaps in internet access. The coverage in rural areas is just half that of the coverage in cities. Finally, preliminary data and anecdotal evidence suggest internet usage increased significantly during the COVID-19 pandemic (Rahul 2020).

Buoyed by its fast-growing usage, the internet is generating previously inconceivable volumes of data with enormous knowledge-enhancing potential, if combined with the right tools to extract information. Against this backdrop, governments are investing large resources in internet-based innovations and data analytics, including machine learning and other artificial intelligence innovations. For instance, in fiscal year 2021, the United States government spent \$90.9 billion

⁴ Coase and Williamson, on the one hand, and Douglas North on the other hand.

⁵ A broader institutional environment includes regulatory, social, and infrastructure services.

⁶ The chapter does not discuss the opportunities technological innovations and big data offer private business, even though more transparent private sector operations can reduce the supply of corruption significantly. See World Economic Forum (2020) for some private sector applications.

on information technology, amounting to 1.1 percent of the budget (IT Dashboard 2020; OMB 2020). In China, spending on research and development climbed to \$378 billion in 2020 (2.4 percent of GDP) from \$322 billion in 2019.⁷ These investments aim, among other things, to collect data and find patterns and statistical relationships between variables, predict socioeconomic trends, support early warning systems, and ultimately fine-tune policy formulation and monitoring. While the internet facilitates transparency and participation,⁸ big data analytics improves the ability of governments to make short-term predictions (including nowcasting) and allows reducing public officials' discretion in policy-making and hence corruption vulnerabilities.

Recent Trends in E-government

The United Nations E-Government Development Index (EGDI), compiled since 2001, helps track the adoption by governments of internet-based innovations in their interventions. EGDI is a normalized (0 to 1 scale) composite index with three components: (1) the Online Services Index (OSI), which measures governments' capability and willingness to adopt the internet in the delivery of public services to its citizens and the extent to which these services are accessible and integrated; (2) the Telecommunication Infrastructure Index (TII), which measures the quality of the existing infrastructure to deliver e-services to the population; and (3) the Human Capital Index (HCI), which measures the intrinsic ability of populations to use e-government services. The EGDI is available for 193 countries as the arithmetic average of the three-component indices.

Over the past twenty years, governments worldwide have consistently intensified the use of internet-based innovations in their operations, with the global average of the E-Government Index increasing from 0.35 in the early 2000s to 0.61 in 2020. Most of the advances have happened during the last 10 years with the acceleration in the provision of digital government services, such as business registrations and applications for business licenses and birth certificates. In 2020 the average world citizen used 14 different online transactional public services, and around six out of every seven countries in the world offered at least one digital government transaction. At the regional level⁹, all country groups

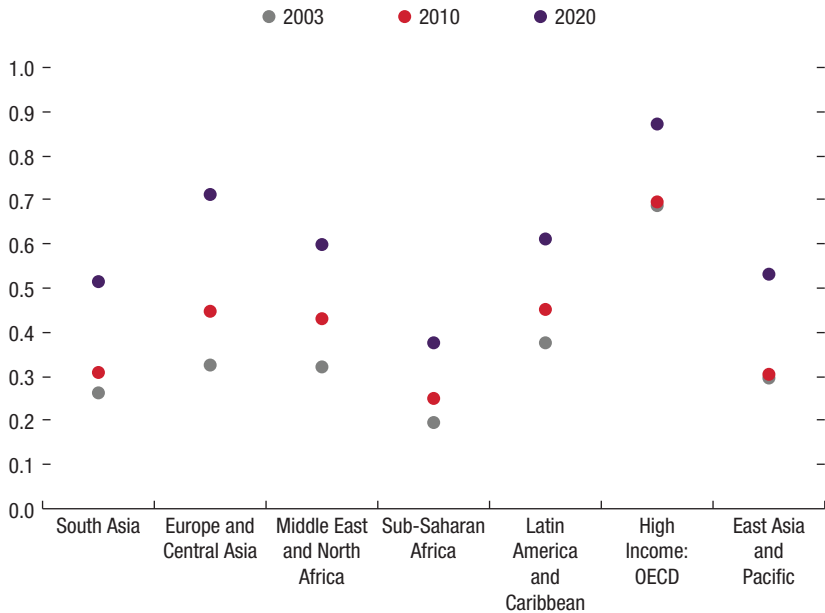
⁷ National Bureau of Statistics of China, "Communiqué on National Expenditures on Science and Technology in 2019," news release, August 28, 2020, http://www.stats.gov.cn/english/PressRelease/202008/t20200828_1786511.html; National Bureau of Statistics of China, "Statistical Communiqué of the People's Republic of China on the 2020 National Economic and Social Development," February 28, 2021, http://www.stats.gov.cn/english/PressRelease/202102/t20210228_1814177.html.

⁸ The terms "e-governance," "e-democracy," and "digital governance" reflect the efforts of governments to go beyond e-government by building stronger partnerships with civil society and citizens through support of participation, accountability, and democracy.

⁹ Regional Grouping based on list provided by International Monetary Fund, World Economic Outlooks (Annex 14.8.1) (IMF 2021b)

improved their e-government intake over the last two decades (Figure 14.1). OECD countries remain in the lead (0.87), followed by Europe and central Asia (0.72), Latin America and the Caribbean (0.61), the Middle East and North Africa (0.60), East Asia and the Pacific (0.53), South Asia (0.52), and sub-Saharan Africa (0.38). Unlike other regions, sub-Saharan Africa has not reduced its e-government gap with OECD countries. The average difference in the E-Government Index of other regions with the OECD's declined by 9½ points, while sub-Saharan Africa remained about 50 points below the OECD throughout the period.

Figure 14.1. E-Government Index
(By region)

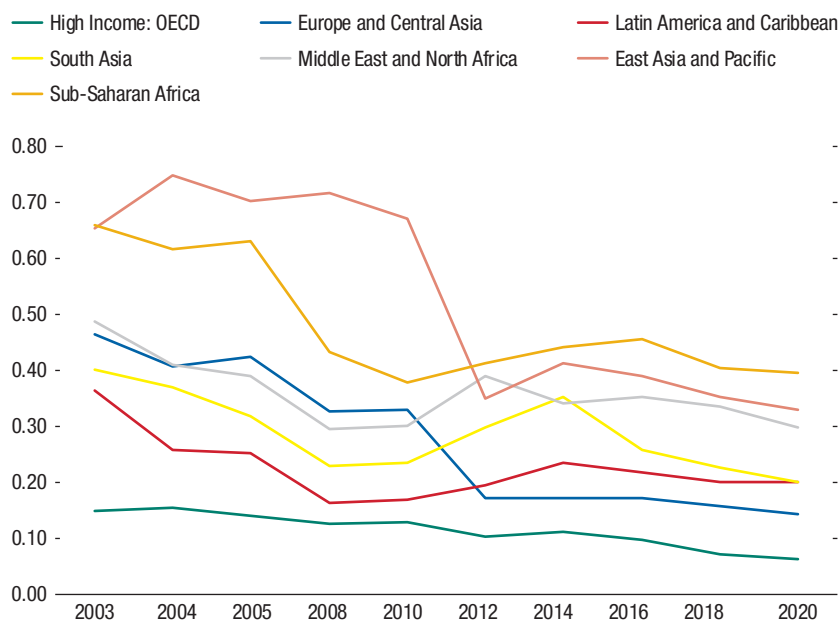


Source: United Nations E-Government Development Index.

Of course, average regional scores mask high variation of the level of e-government within each region. This within-region volatility is negatively correlated with the region's average performance. For instance, sub-Saharan Africa's top performer (Mauritius) is far more advanced than the country with the lowest score (South Sudan), while the difference between the top and bottom performers in the OECD is much lower (Figure 14.2).

Figure 14.2. E-Government Index Volatility

(By region; 2003–20)

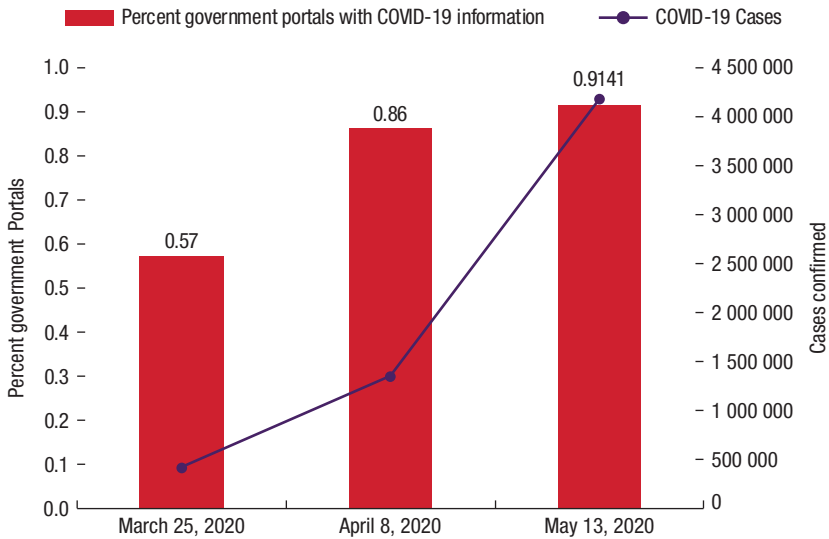


Source: United Nations E-Government Development Index.

Note: Coefficient of variation = standard deviation / mean. Coefficient of variation is presented.

During the COVID-19 pandemic, digital government services played a critical role in accelerating policy responses to save lives and livelihoods. For example, these technologies helped keep people connected through hackathons, enabled work continuity and online service delivery, and facilitated the enforcement of stay-at-home measures through text messaging. To support vulnerable households, many governments used direct cash transfers. In countries with a large informal sector, where these transfers are difficult to administer, digital solutions helped deliver the support securely and in a cost-effective manner by identifying and validating recipients. The use of digital solutions was effective in countries where the authorities were able to adapt quickly by streamlining public financial management procedures (IMF 2020a). In many countries, local governments supported the response by establishing portals with information on the disease's local prevalence, regular policy updates, and guidance on receiving government assistance. Successful local e-government initiatives included (1) Vancouver's online dashboards to enable citizens to track the city's emergency response; (2) the Western Cape's online platform for remote teaching; (3) Sichuan's use of chatbots to assess patients' infection risks and use of 5G+ telemedicine to improve health care outcomes; and (4) London's use of smart city technology to control social distance through traffic control cameras, sensors, and algorithm-based control devices (Hong and others 2020; United Nations 2020).

Figure 14.3. Government Portals with COVID-19 Information and World Total Confirmed Cases



Sources: UN DESA (2020) and World Health Organization.

Countries that were hit hardest by the pandemic in 2020 were, luckily, already enjoying a high utilization of e-government. As the number of COVID-19 cases increased, their governments leveraged the existing IT infrastructure to devote more online resources to the fight against the pandemic (Figure 14.3). The percentage of government portals with COVID-19 information increased by more than 60 percent between March and May 2020. Notwithstanding the head start of more advanced countries, Africa hosted 12.8 percent of technologies developed to respond to the pandemic, of which 58 percent were ICT-driven, according to the WHO (Anderson 2020). These innovations included (1) online applications launched in Sierra Leone to improve the government's ability to track quarantine periods and other services like food delivery, (2) robots and drones deployed in Rwanda to reduce health workers' contacts with potential positive COVID-19 patients and thus contamination risks, and (3) South Africa's chatbots to reduce the spread of false information on the disease.

Recent Trends in Institutional Quality

As in Bruinshoofd (2016), institutional quality or the quality of governance¹⁰ can be measured with the six Worldwide Governance Indicators complemented by the Ease of Doing Business Index: (1) "voice and accountability" measures the extent to which citizens can select and challenge the government; (2) "political stability

¹⁰ These two terms are used interchangeably in the chapter.

and absence of violence” accounts for how much citizens are incentivized to invest in their future; (3) “government effectiveness” stands for the quality of public services and the administration’s degree of independence from political pressures; (4) “regulatory quality” measures the ability of the government to formulate and implement sound policies and level-playing-field regulations; (5) “rule of law” captures the enforcement quality of society’s rules (contract, property rights, police, courts, and so on); (6) “control of corruption” links economic success to effort and competence, rather than connections and bribery; and (7) “ease of doing business” measures the extent to which the regulatory environment is conducive to business operation.¹¹ While this compositive indicator of institutional quality can help track progress over time and across regions, it has serious limitations, including recent irregularities in reporting the doing business indicators.¹²

Worldwide, progress on institutional quality has been less impressive than on e-government; notably, there were even relapses on institutional quality during the 2000s. This degradation reflects setbacks in the Middle East and North Africa and in Latin America and the Caribbean. South Asia and sub-Saharan African countries also saw their overall index of governance slip, albeit less drastically. Throughout the last 20 years, the high-income OECD group has enjoyed by far the best overall governance, while sub-Saharan Africa has remained the region with the worst overall governance indicators (Figure 14.4). All the other five regions recorded changes in their governance standing relative to peers. East Asia and the Pacific, with the second-best overall indicator, overtook Latin America and the Caribbean. Each of these three regions—East Asia and the Pacific, Latin America and the Caribbean, OECD—enjoyed above-average governance status throughout the period. The other four regions, which remained below the world average, were led in 2020 by Europe and Central Asia (ECA). In turn, the indicators for ECA rapidly approached those of regions with higher governance indicators, followed by South Asia, whose scores converged with those of the higher-scoring regions, albeit at a slower pace. The Middle East and North Africa and sub-Saharan Africa’s indicators slipped deeper into negative territory.

The main drag on world governance performance stems from political stability and absence of violence/terrorism, the only indicator showing a worldwide decline between 2000 and 2019. Most of the worsening security and attendant political instability reflects the 9/11 terrorist attacks on the United States and

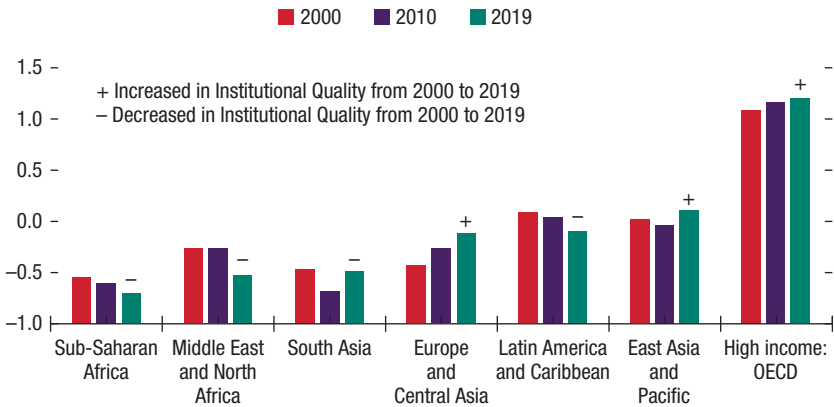
¹¹ Use of these indicators should be considered carefully, as they are derived from perceptions-based data. The CPI uses a scale of 0 (highly corrupt) to 100 (very clean). The WGI give scores on aggregate indicators, in units of a standard normal distribution (ranging from -2.5 to 2.5).

¹² See World Bank, “Doing Business—Data Irregularities Statement,” news release, August 27, 2020, <https://www.worldbank.org/en/news/statement/2020/08/27/doing-business--data-irregularities-statement>; and Reuters, “World Bank Halts Country Business Climate Rankings to Probe Data Irregularities,” news release, August 27, 2020, <https://www.reuters.com/article/us-worldbank-data-review/world-bank-halts-country-business-climate-rankings-to-probe-data-irregularities-idUSKBN25N28J>, and “The World Bank’s Doing Business Report”, Congressional Research Services, October 29, 2021, <https://crsreports.congress.gov/product/pdf/IF/IF11959>.

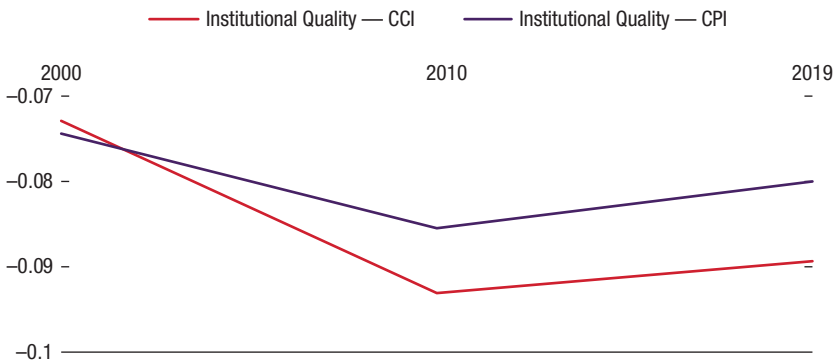
Figure 14.4. Governance on Institutional Quality

(By region; 2000–19)

1. Institutional Quality Average



2. Worldwide Governance



Sources: Doing Business Index; Transparency International; and Worldwide Governance Indicator.

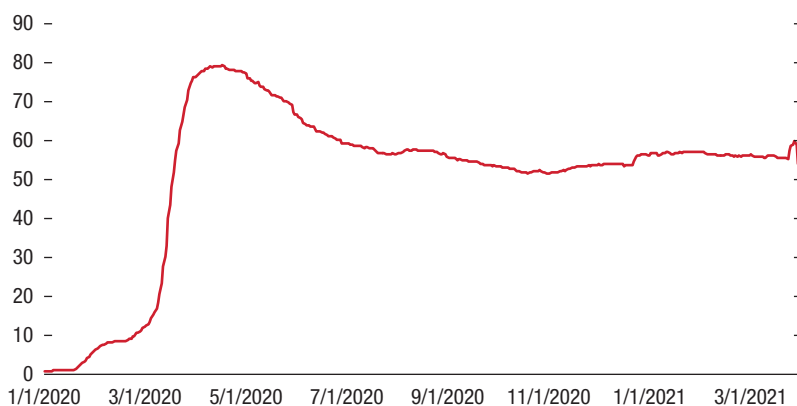
Note: CCI = World Bank Group, Control of Corruption Index; CPI = Transparency International, Corruption Perception Index.

their worldwide repercussions. The regions that experienced the most significant security issues are the Middle East, with the largest number of ongoing conflicts (International Crisis Group 2020). The Latin America and Caribbean region experienced massive antigovernment protests beginning in 2000, including the general oil strike in Venezuela (Murphy 2002), causing lasting economic and social damage. High-income OECD countries, especially those involved in the response to the 9/11 attacks, also saw an increase in the number of attacks in their territory. Sub-Saharan Africa started to experience an increase in terrorism-linked violence after 2010 in the aftermath of the conflict in Libya that led to the creation of the G5 Sahel (Burkina Faso, Chad, Mali, Mauritania, Niger) to manage the instability through international cooperation.

Significant progress on the rule of law was also elusive in the conflict regions and South Asia. The fastest progress was recorded for the following indicators: (1) doing business, with recent reforms (including to eliminate paid-in capital requirements and digitize filing and payment systems) in Europe and Central Asia; the upward trend was reinforced by progress in South Asia, which became the second business-friendly region, behind high-income OECD countries (World Bank 2020a); (2) voice and accountability, thanks to advances in South Asia and in Europe and Central Asia; and (3) control of corruption, buoyed by reforms in the Europe and Central Asia and the East Asia and Pacific regions. These two regions have also enjoyed significant gains in government effectiveness and regulatory quality. While data are not available to measure governance in 2020 and ascertain the impact of the COVID-19, the pandemic probably impacted governance adversely. Indeed, as can be seen during previous crises, fragility and crises tend to weaken governance as uncertainty and governments' openness to emergency solutions create conditions for rent-seeking behaviors.

As discussed, the security crisis in the Middle East and North Africa region underpinned the rapid worsening of governance indicators. Following the West Africa Ebola health crisis, there was a significant increase in governance issues in the management of emergency funds to finance mitigation, relief, and recovery efforts. During the COVID-19 pandemic, in some regions, lockdowns and other containment measures helped control the spread of the virus by restricting civil rights (such as mobility). The Oxford Stringency Index (Figure 14.5), which peaked around 80 for an index capped at 100, suggests significant impairments of voice and accountability, including from postponement of elections and the rule of law, as some of the containment measures were inconsistent with laws and regulations in normal times.

Figure 14.5. COVID-19 Worldwide Governance Stringency Index
(January 2020–March 2021)

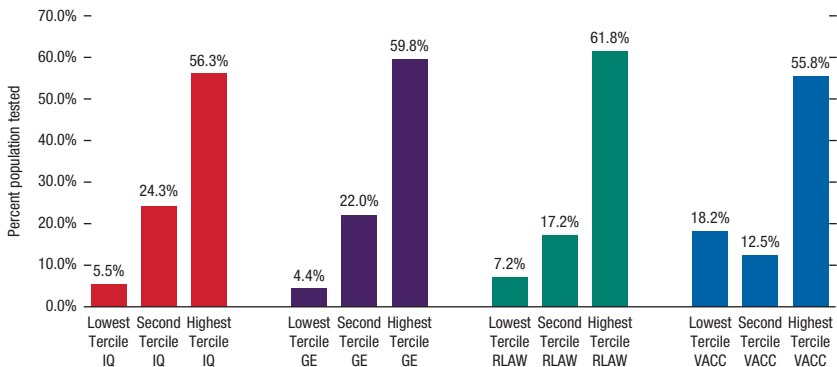


Source: Government Stringency Index, OxCGRT Project; and Hale and others (2020b).

Note: X-axis is the date; y-axis is the Stringency Index between 0 and 100 (100 = strictest response).

Regardless, governments with higher governance standards are exhibiting better responses in the control of the COVID-19 pandemic. In publishing its 2020 Corruption Perception Index (CPI), Transparency International argued, “COVID-19 is not just a health and economic crisis. It is a corruption crisis.” That is, because countries with lower perceived corruption invest more in health care, including testing; are better able to provide universal health coverage and to face the pandemic; and are less likely to violate democratic norms and institutions or the rule of law in combatting the pandemic. Figure 14.6 shows that good governance positively impacts the ability of countries to test for COVID-19 (Kaufmann 2020). Countries in the highest quantile of institutional quality (IQ), government effectiveness (GE), rule of law (RLAW), and voice and accountability (VACC) indicators tend to have higher COVID-19 testing ability and lower positive cases rate as a share of tests.¹³ Among countries with the highest institutional quality ranking in 2019, many have addressed the pandemic well. For instance, New Zealand, ranked first in the 2019 institutional quality indicator, has excelled in controlling the pandemic. The seven-day rolling average of confirmed cases saw a decreasing trend only one month after the outbreak of March 2020, and there were fewer than 20 cases confirmed each day as of the beginning of 2021. Singapore, ranked sixth in the 2019 institutional quality indicator, has the world’s lowest COVID-19 death rate, and is among the countries with the lowest number of daily confirmed cases (Geddie 2020). On the contrary, many countries in the bottom of the Governance Index, are among largest contributors to the world COVID-19 caseload (Our World Data 2021).

Figure 14.6. Percent of Population Tested for COVID-19
(By quality of governance)



Sources: Kaufmann (2020); Worldometers (2021) and World Governance Indicator.

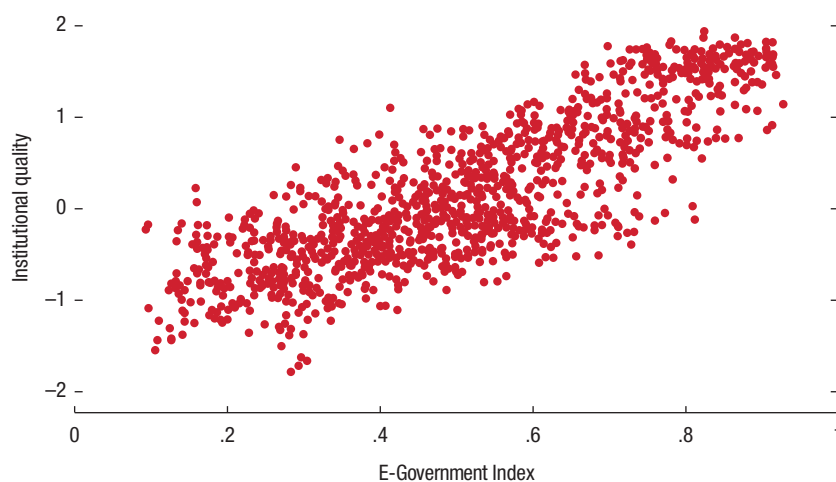
Notes: IQ = Institutional quality; GE = Government effectiveness; RLAW = Rule of law; VACC = Voice and accountability.

¹³ Based on COVID-19 total cases divided by total tests population.

Leveraging Technology and Human Capital to Enhance Governance

Adoption of e-government can play a crucial role in the improvement of the quality of institutions. Indeed, the scatter plot in Figure 14.7 shows strong and positive comovements between e-government and institutional quality. Regressing institutional quality against the E-Government Index (EGI) and the Human Development Index (HDI)—to capture the level of development—indicates that e-government is significantly and positively correlated with institutional quality. The regressions of institutional quality on e-government sub-components, controlling for the level of development, suggest that changes in institutional quality are closely associated with variations in the quality of telecommunications infrastructure and in human capital (Annex 14.1). Online services are not significantly correlated with institutional quality, though it is generally admitted that publicly accessible, good-quality information on government services is critical for transparency and reduces transactions between public service users and government officials and corruption vulnerabilities.

Figure 14.7. Comovements between Institutional quality and E-Government



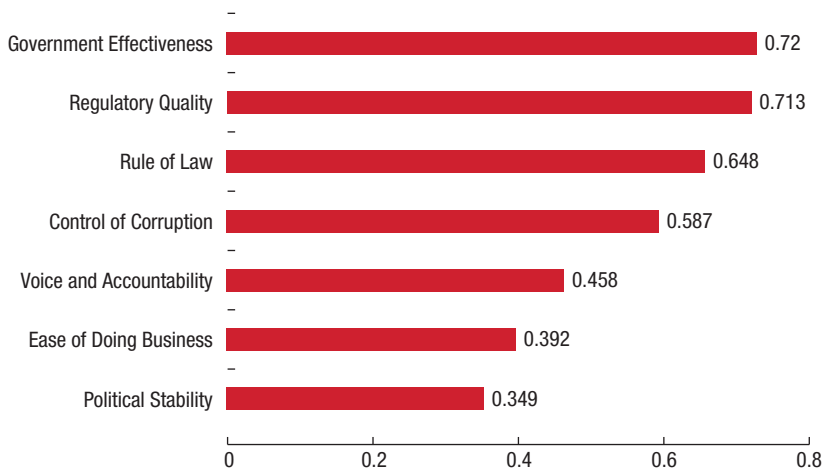
Sources: World Bank Group; World Governance Indicator; and UN E-Government databases.

Note: The institutional quality composite score is calculated using the average of subindicator. Doing Business Index was normalized using the z-score method.

The counterintuitive result that changes in online services are not associated with institutional quality variability in the regressions could be because telecommunication infrastructure and human capital capture the relevant variability of online services for governance. In other words, online services can affect institutional quality only in the presence of good telecommunications infrastructure and

adequate education level, which enable users to extract benefits from online services (threshold effects). West (2015) identified poverty, high charges (for device, data, and telecommunications), poor infrastructure, digital illiteracy, and policy and operational obstacles as significant barriers to internet access in low-income countries. In these countries, investments in top-notch online services will not bear fruit fully if the population does not possess adequate education and skills to search for the relevant services or if telecommunication infrastructure is too poor to sustain demands at affordable prices. The regression of each of the seven components of the institutional quality indicator on the E-Government Index gives insights on how e-government covaries with governance (Figure 14.8). The results suggest a more than 50 percent conditional correlation of e-government with government effectiveness, regulatory quality, the rule of law, and control of corruption. Changes in e-government are correlated with more than 40 percent of the variability in voice and accountability, and more than 30 percent of the variability in the Ease of Doing Business Index and political stability.

Figure 14.8. Predictive Power of E-Government on Governance Component
(Adjusted *r*-squared)



Sources: Transparency International, Corruption Perception Index; World Bank Group, Global Governance Indicator, Doing Business Index; and United Nations Development Program.

Note: The regressions include the Human Development Index to control for the level of development.

The regressions of each of the subcomponents of institutional quality on the e-government subindices provide additional guidance on how e-government influences institutional quality. The results (Annex 14.2) indicate the following:

- Telecommunication infrastructure and human capital have a consistent positive and highly significant association with all the dimensions of institutional quality.

- Telecommunication infrastructure displays the highest marginal association with each of the governance subcomponents, except for the ease of doing business indicator, which is linked primarily to human capital. This suggests that e-government strategies that aim to enhance governance should prioritize investments in telecommunication infrastructure. Further, the results provide preliminary indications that the impact of investments in telecommunication infrastructure is larger for control of corruption.
- Human capital's association with governance, in order of importance, goes through voice and accountability, ease of doing business, government effectiveness, and regulatory quality. Control of corruption, the rule of law, and political stability are also positively and significantly associated with human capital, albeit with less strength.
- Finally, online services' covariance with governance is more nuanced. The online service variable is positively associated only with ease of doing business, regulatory quality, and government effectiveness. It does not have a significant association with rule of law, control of corruption, and voice and accountability. The online service variable is negatively and significantly associated with political stability and the absence of violence and terrorism. This latter result suggests that online services can even provide potent support for organizations promoting violence. Indeed, proponents of violence can take advantage of the right to freedom of expression in national and international laws to share content in support of their causes (UNODC 2012).

Panel data techniques allow further analysis of the impact of e-governance on corruption and government effectiveness. By leveraging the additional information and variability from the combination of pure time series and cross-sectional data, panel data analysis can detect and measure statistical effects that escape unidimensional analyses. Additionally, panel data can eliminate or reduce the impact of omitted variables using the intertemporal dynamics of the data (for a detailed presentation of the advantages of panel data techniques, see Hsiao 2005). The fixed effects models assume that the impact estimates are identical, whereas the random effects models assume these estimates vary, which makes the random models more easily justified (Borenstein and others 2009).

The focus on corruption reflects the existence of theoretical models of corruption, which allows the identification of estimates from statistical models and a rationalization of investments in e-government. Tirole (1986) offers a concise framework for corruption modeled as collusion between an agent (a public official) and firms or individuals (a third party) supervised by the agent on behalf of the principal (government), who has an information disadvantage regarding the actions of the third party.¹⁴ In this framework, when markets are competitive, the probability of collu-

¹⁴ Klitgaard (2015) offers an even more straightforward characterization in a formula equating corruption to a combination of monopoly, discretion, and lack of accountability: $\text{Corruption} = \text{Monopoly} + \text{Discretion} - \text{Accountability}$.

sion increases with the information gap between the principal and the agent, and with the agent's discretion to decide on behalf of the principal. Investments in e-government represent the principals' cost to reduce their information disadvantage through more transparency and reduce the agent's discretion by mandating the systematic use of big data and data analytics in policymaking.

The results of the panel regressions confirm the positive and significant relationship between e-government and control of corruption and government effectiveness (Annex 14.3).¹⁵ Countries that fare better on the different dimensions of e-government enjoy more effective government and less corruption. The results are also comparable with the findings of Shim and Eom (2008) and Zhao and Xu (2015), who showed the critical role of e-government in lowering corruption. As shown in previous results, human capital and telecommunication infrastructure are the most important pillars for reducing corruption and enhancing government effectiveness. Online services positively and significantly affect control of corruption and government effectiveness.

These results are in line with recent empirical studies that provide evidence of how e-government contributes to fighting corruption (Owusu-Oware, Effah, and Boateng 2018; Zhao and Xu 2015). However, based on the research conducted for this chapter, no empirical study has established a causal relationship and the direction of causation between e-government and the quality of governance. While Granger causality tests cannot fill this gap, they can help establish statistical precedence between institutional quality and e-government. The analysis documents conditional correlations that could offer insights to policymakers and stakeholders of governance reforms on the dividends of digitalization. The results (Figure 14.9) show that e-government Granger causes institutional quality, but institutional quality does not Granger cause e-government (in the sense of temporal precedence). This direction of Granger causality means that policymakers should prioritize robust e-governance strategies to improve the population's living conditions through improvements in the overall quality of institutions. The results also show no causal relationship (in the sense of Granger) between online services and overall institutional quality. Human capital and telecommunication infrastructure Granger cause institutional quality but are not caused by institutional quality. Also, there is no governance subcomponent that is not Granger caused by at least one of the e-government variables, and all dimensions of e-government cause control of corruption. This last result gives support to the proponents of investments in e-government to curb corruption. Further, Figure 14.9 shows the following¹⁶

¹⁵ The Random Effect Model is preferred to assess the relationship because of its better fit indicators. In addition, the use of robust standard errors complicates the implementation of the Hausman test, which is assessed to overreject the null hypothesis (Sheytanova 2014).

¹⁶ The Granger causality test is based on the null hypothesis that x does not Granger cause y . The alternative hypothesis is x does Granger cause y for at least one panelvar (countrynum). At a 90 percent confidence level, the null hypothesis is rejected if p -value < 0.05 .

Figure 14.9. Assessing Precedence between E-Government and Institutional Quality

		EGDI Components			
Institutional Quality Components	Y: EGDI	E-Government Index	Telecommunication Infrastructure	Human Capital	Online Services
	Z: WGI				
	Institutional Quality				X
	Voice and Accountability			X	X
	Rule of Law	X		✓	X
	Regulatory Quality	X		✓	X
	Political Stability	X	✓		X
	Government Effectiveness	X	✓	✓	X
	Control of Corruption	X		✓	
Legend:		Y causes Z			
Z causes Y		✓	Y does not cause Z		
Z does not cause Y			X		

Source: Authors' estimations and calculations.

Note: EGDI = E-Government Development Index; WGI = World Governance Index. Details of the Granger causality tests are in Annex 14.4.

- Telecommunication infrastructure Granger causes all governance dimensions but is not Granger caused by voice and accountability, rule of law, regulatory quality, or control of corruption. Telecommunication infrastructure is Granger caused only by political stability and government effectiveness, which can thus be viewed as important pillars to boost investment in telecommunication infrastructure.
- Human capital Granger causes all Institutional Quality components, except voice and accountability. Human capital has bidirectional causal relationships with rule of law, regulatory quality, government effectiveness, and control of corruption.
- Online services Granger cause corruption but are not Granger caused by corruption. There is no Granger causality relationship between online services and any other governance variable.

PROMOTE MACROECONOMIC STABILITY THROUGH INTEGRITY-FRIENDLY TECHNOLOGY

The view in Acemoglu and others (2002), that poor macroeconomic policies are symptoms of underlying institutional problems rather than the main causes of economic volatility, suggests that sustained growth and stability require good governance. The results discussed in the previous section are in line with studies that have established the positive impact of e-government on institutional quality and the powerful relationship between the introduction of ICT and data innovations and control of corruption, which also trigger changes in human capital. Olken and Pande (2012) provide a simple framework to show that corruption can be fought by increasing the expected cost of crime, which in turn is achieved by

increasing the probability of catching offenders. This result holds in a highly corrupt environment where high-level officials supposed to organize the monitoring of economic activities are themselves corruptible. Monitoring can be provided through audits or through transparency. Both provide information about government actions to citizens who can better monitor government officials and enforce greater accountability.¹⁷ ICT and data innovations provide tools that can safeguard the integrity of established processes (Duflo, Hanna, and Ryan 2012) and facilitate monitoring, including through audits and transparency. Mechanisms through which technology can stem corruption vulnerabilities include putting checks on public officials' discretion and gathering enough data on them to prevent and uncover corruption.¹⁸ Typical areas for such mechanisms are revenue mobilization and spending efficiency, given their importance for macroeconomic stability, especially during crises such as the COVID-19 pandemic.

E-Government to Mobilize Revenue through Less Corruption

IMF studies suggest that highly corrupt countries lose up to 4 percent of GDP in revenue to corrupt activities; furthermore, if all countries were to reduce corruption in a similar way, they could gain \$1 trillion in lost tax revenues, or 1.25 percent of global GDP (IMF 2019a; 2019b). Countries in which the government is representative and can be challenged by citizens experience less political interference related to favoring supporters or harassing opponents and less nepotism in the appointment, selection, transfer, and promotion of tax officials. Control of corruption mechanisms, including more frequent investigations, can reduce the likelihood of tax officials either being bribed or embezzling funds by increasing the probability of detection and punishment (Fossat and Bua 2013). Effective governments can better deter smuggling and undervaluation of turnovers by taxpayers (Martini 2014). To illustrate the importance of government effectiveness, Yang (2008) finds that through transmission of information, preshipment import inspection programs increased import duty collection by 15 to 30 percentage points by improving the monitoring ability and reducing the bargaining power of corrupt customs officials. Kleven and others (2010) find that the tax evasion rate in Denmark on self-reported income is substantially larger than for income subject to double reporting, which, however, requires skilled tax officials and effective revenue agencies.

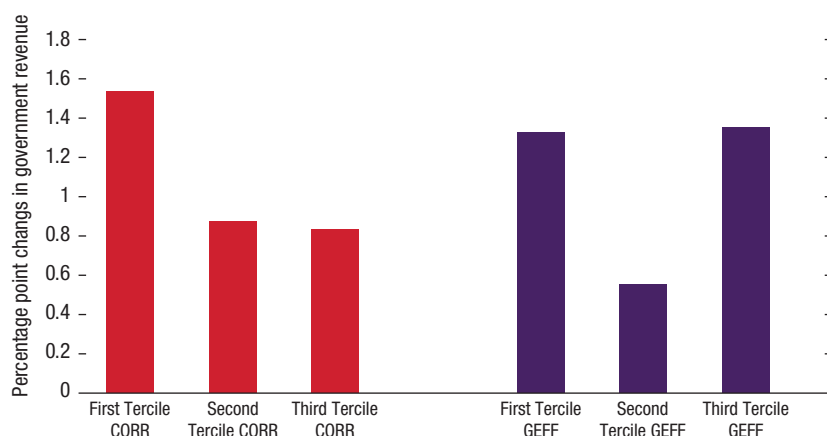
Measures to reform tax administration have been successful in raising revenue by acting on several of the levers discussed in this chapter (especially capacity of tax administrations) but increases in revenue have not necessarily come from lower

¹⁷ Djankov and others (2010) find that public disclosure of politicians' assets, liabilities, income sources, and potential conflicts, as opposed to simply income and wealth levels, is more consistently associated with better government and lower perceived corruption.

¹⁸ Such data include public officials' income and assets, their roles in awarding contracts, their company board memberships, their holdings of stocks and shares included in financial disclosures, company registry data, tax declarations, taxpayer IDs of firms and public officials, tax activity of firms (shell companies), and financial intelligence data such as suspicious transactions abroad.

corruption. Figure 14.10 shows that countries that made the least progress on corruption (first tercile) are those that recorded the fastest gains in revenue. Over the last two decades, sub-Saharan Africa recorded significant gains in revenue collection (1.2 percentage points of GDP), while its control of corruption index worsened slightly. These facts suggest sub-Saharan Africa still enjoys significant potential for raising more revenue through reducing corruption. Against this backdrop and amid increasing demands for tax transparency, recent reforms emphasize reducing corruption in the process of collecting revenue (Moore 2013) by (1) limiting tax officials' discretionary powers; (2) increasing the autonomy of tax administrations and introducing measures to heighten their resistance to political interference; and (3) strengthening monitoring and oversight of the ethics and integrity of all mid- to senior-level tax officials, including mandating asset declarations for all such officials. E-government can facilitate the achievement of these objectives, and modern revenue agencies can systematically use data analytics to develop a picture of companies' tax profiles and decide on tax and audit assessments; data analytics can also help identify patterns and irregularities in tax officials' asset declarations or appearances in property registries. In other words, ICT and data innovations can improve government revenue through lower corruption, contrary to the previous generation of reforms. These reforms are also more equitable and more sustainable.

Figure 14.10. Revenue Enhancement amid Corruption
(2010–2019)



Sources: World Bank Group, World Governance Indicator; and authors' calculations.

Note: CORR = Control of Corruption; GEFF = Government Effectiveness Index. Tercile groups were ranked based on absolute changes in CORR and GEFF. There are a total of 160 countries: First is the lowest and Third is the highest.

The extent to which e-government increases the association between corruption and revenue collection can be assessed through transformations and tests to a baseline regression of revenue on indicators of institutional quality, controlling

for income level. Results from this baseline regression (Annex 14.5) are in line with the positive and significant impact of control of corruption, voice and accountability, and government effectiveness on revenue performance found by other studies.¹⁹ While these results provide hints on the relationships between these variables, they are fraught with statistical problems and biases, including ones from omitted variables and endogeneity:

- The omitted variable bias can be assessed by sequentially adding e-government variables individually and jointly to the regression of government revenue on institutional quality. The results show that the added e-government variables are relevant in the statistical relationship between governance and government revenue, because their coefficient estimate is significant (Annex Table 14.5.1), and their introduction reduces the bias in the original coefficient estimate of corruption, which converges toward the true value of the correlation between corruption and government revenue (Annex Figure 14.5.1). These results lend credit to the important role played by e-government in the explanation of changes in government revenue.
- Interacting the variables suggests that, overall, the Human Capital and Telecommunication Infrastructure Index boosts the correlation of corruption and revenue (Annex Table 14.6.1). Thus, these two variables should be considered together to arrive at positive outcomes (Fjeldstad 2003; 2006; Fossat and Bua 2013; Moore 2013). Regressions by region (Annex Table 14.6.2) suggest that the interaction of control of corruption with e-government variables has the largest effect (1) in the Middle East and North Africa, where all three e-government variables interact positively with corruption to enhance government revenue; and (2) in sub-Saharan Africa, where the correlation of corruption and revenue is boosted by human capital and telecommunication infrastructure. This shows that the impact of e-government reforms to boost revenue collection by reducing corruption is even larger in poor countries with low-paid civil services and in countries where gift giving is a dominant cultural trait (Graycar and Jancsics 2016).
- The endogeneity bias is addressed by using instrumental variables (Annex 14.7) with a two-stage least-squares estimation method. The coefficient estimate of control of corruption in the baseline regression of government revenue is positive and significant. The point estimate of 0.0157 suggests that an improvement from the lowest quintile of control of corruption to

¹⁹ The results also suggest that regulatory quality and rule of law are negatively associated with revenue. While this latter finding is counterintuitive, it is conceivable that complex laws can facilitate extortion of taxpayers when taxpayers have weak capacity and understanding of tax laws, especially when there is a lack of adequate monitoring and supervision of tax officials (Puhorit 2007; Rahman 2009). Likewise, sound regulatory quality can hinder the collection of tax revenue when tax laws and regulations are sponsored and captured by well-connected companies, and when revolving doors allow the use by former tax officials of insider knowledge for private gain.

the median performer²⁰ would be associated with an increase in government revenue by 1.46 percentage points of GDP. The point estimate turns negative and loses its significance with a two-stage least-squares regression with human capital and telecommunication infrastructure as instrumental variables.²¹ This means that the impact of corruption on government revenue goes through these two dimensions of e-government, which are endogenous in the explanation of revenue by corruption.

Promoting Value for Money through E-Government

Poor governance in public financial management exposes massive amount of public wealth and income to corruption. Procurement is often presented as one of the most corruption-prone government activities, in view of the amounts at stake and the complexity and frequency of interactions between public officials and private businesses.²² In response, governments are moving to online procurement platforms to prevent corruption and to promote better service delivery by increasing access to information and making their procurement systems more transparent.²³ IMF's Expenditure Assessment Tool has also identified inefficiencies, including from corrupt practices, in other areas of public spending, such as the wage bill and subsidies and transfers. An IMF study (IMF 2020d) also shows that an average country loses about 30 percent of the returns on its investment to inefficiencies, including corruption in the appraisal, design, and implementation of projects. Government spending is even more vulnerable during emergencies such as the COVID-19 pandemic or the 2014 Ebola outbreak, given the need to execute the spending speedily.²⁴ This explains the emphasis civil society organizations put on transparency during crises to stem corruption and ensure the relief reaches its intended purpose (TI, HRW, and GW 2020). In the April 2020 *Fiscal Monitor*, the IMF called on government "to do what it takes, but to keep the receipts," highlighting the importance of ensuring fiscal transparency, public accountability, and institutional legitimacy (IMF 2020b).

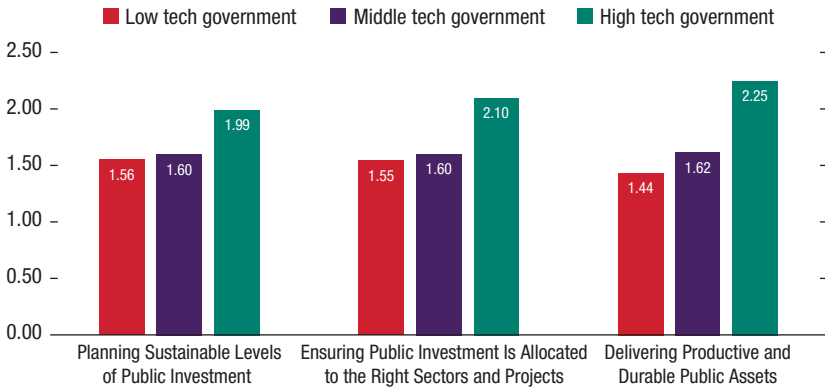
²⁰ The difference between the midpoint of the first quintile (–1.16) to the index of the median performer (–0.23) is 0.93.

²¹ The choice of instrumental variables was made by regressing corruption on the three e-government variables. Online services is not significant and thus not a good instrument.

²² According to OECD (2017a), 57 per cent of foreign bribery cases are due to procurement corruption.

²³ Lewis-Faupel and others (2016) find that electronic procurement leads to higher quality of roads, as measured by independent central government audits, though not to lower costs. The evidence suggests that the quality improvement comes from higher-quality contractors being more likely to win contracts.

²⁴ The IMF estimated COVID-19-related spending at about \$9 trillion six months into the crisis. Most of the spending was carried through extrabudgetary funds (EBFs) to hasten the delivery of relief by streamlining budgeting, spending, and procurement processes (see Chapter 11). The spending covered the promotion of research on the disease and vaccine, face masks, social distancing, testing, and tracing and isolation of suspected cases; the enforcement of lockdowns; the distribution of aid to households and firms to protect countries' human and social capital; and the provision of health care for sick people.

Figure 14.11. Public Investment Management Assessment and E-Government

Sources: IMF's Fiscal Affairs Department and UN e-government data.

Several databases provide useful insights into the quality of public spending processes and how the outcomes of public spending are linked to their costs. These databases include the IMF's Public Investment Management Assessment (PIMA)²⁵ and Expenditure Assessment Tool, and the World Economic Forum's Expenditure Wastefulness Index.^{26,27} Figure 14.11 indicates that low-tech countries lag countries with higher e-government intake on the planning and allocation of public investment, and importantly are less productive and have less durable public assets. Regression analysis suggests e-government accounts for 53 percent of the volatility in delivering productive and durable assets, 40 percent of the volatility of the quality of public investment allocation, and 31 percent of the volatility of the quality of investment planning. These results are confirmed by crossing data from WEF's Spending Wastefulness Index and E-Government Index: on average, the most advanced fifth in terms of e-government has a spending effectiveness perception 30 percent better than that of the least advanced fifth.

During the COVID-19 pandemic, e-government helped bolster the governance of public resources through (1) the establishment of dedicated portals to publish information on the execution of COVID-19 spending (Côte d'Ivoire, Gabon, Honduras, etc.); (2) the exclusive use of e-transactions and e-procurement to simplify the maintenance of transaction records; (3) granting access to other relevant databases—such as those maintained by the national revenue authority or social services—to

²⁵ PIMA is a comprehensive framework that evaluates countries' infrastructure governance practices through 15 institutions involved in planning, allocation, and implementation of public investment.

²⁶ The index is not based on any objective economic or accounting measure, but rather by the perceptions of the population. The countries are ranked from 1 (least wasteful) to 140 (most wasteful).

²⁷ Use of these indicators should be considered carefully, as they are derived from perceptions-based data.

identify and pay eligible beneficiaries (Mauritius); (4) the disclosure of the existence of COVID-19 funds on government websites and descriptions of their key characteristics, including their legal mandate, objectives and policy rationale, sources of revenue, governance and management arrangements, and operating rules and procedures; (5) reporting on the revenue and expenditures of the funds monthly or quarterly on a gross basis; (6) conducting interim audits and concurrent controls using information posted on government websites (Honduras, Sierra Leone). These interim audits and real-time audits were instrumental in safeguarding public resources in Sierra Leone during the 2014 Ebola crisis (Chapter 12, this volume; IMF 2021a).

CONCLUSION

This chapter provided illustrations that internet- and data-based innovations can act as powerful enablers of good governance by improving the accuracy of policy-making and by reducing corruption. They promote a culture of transparency and trust in government by limiting officials' discretion in policymaking and conflicts of interest. The chapter's empirical results suggest that policymakers should consider prioritizing e-government to improve the quality of institutions. In addition, the results indicate that e-government strategies that successfully impact governance should be well sequenced, with investments in human capital, institutional capacities, and telecommunication infrastructure taking precedence on the development of a sophisticated offering of government online services. These services should remain in line with the level of education of the population and the ability of the telecommunication infrastructure to deliver them. The results call for further research to understand the low predictive power of online services on governance.

The chapter provided indications that e-government can enhance government revenue mobilization by reducing corruption, in contrast to reforms that enhance revenue collection amid higher corruption. This result suggests that innovation-based revenue reforms are more sustainable and bolsters the case for reforms of revenue-collection agencies that focus on improving governance and reducing corruption through e-government. Such reforms are even more critical in poor countries with a culture of gift giving, given the potential of e-government to reduce human interaction and anonymize public services. The reforms will also help shield revenue agencies from political pressure and support the view that internal decisions on tax assessments and audits are fair and a reflection of tax profiles and risks. In reforming these agencies, policymakers should recognize the critical role good-quality information and a robust telecommunication infrastructure play in preventing corruption and increasing revenue. Preliminary evidence presented in this chapter suggests also that policymakers should consider extending modernization programs to the spending side to improve public investment (including through more transparent public procurement), especially during emergencies. Future work could build on these preliminary findings and address more systematically causality between e-government and institutional quality and the direction of this causality. This could be achieved by exploring additional variables such as random changes in internet access due to external infrastructure changes, among other variables that provide exogenous variation to e-government.

Capacity development will be critical in helping countries improve governance by adopting and absorbing internet- and data-based innovations. The IMF framework for enhanced engagement on governance and corruption issues offers a platform for a discussion with member countries of their governance weaknesses and the identification of capacity development needs to address them. It is important that these discussions cover e-government initiatives, in collaboration with specialized agencies.

ANNEX 14.1.

How E-government Covariate with Governance?

The table below shows the result of the regressions of institutional quality indicators on subcomponents of the E-Government Index (HCI, OSI, and TII), controlling for the level of development with the HDI. Variables from 131 countries in 2003, 2004, 2005, 2008, 2010, 2012, 2014, 2016, and 2018 were used (years for which both E-Government Index and World Governance Indicators are available).

ANNEX TABLE 14.1.1.

E-Government Indicators as Potential Determinants of Institutional Quality		
	(1)	(2)
Variables	Institutional Quality with Corruption Perception Index	Institutional Quality
Human Capital Index	1.085*** (0.110)	1.245*** (0.113)
Online Service Index	0.0274 (0.0756)	0.0468 (0.0777)
Telecommunication Infrastructure Index	2.054*** (0.103)	2.123*** (0.105)
Human Development Index	-0.129 (0.200)	-0.131 (0.205)
Constant	-1.220*** (0.0748)	-1.382*** (0.0768)
Observations	1,157	1,156
R-squared	0.717	0.732

Sources: World Bank Group, Worldwide Governance Indicator; United Nations Development Program, Human Development Index; and United Nations e-government databases.

Note: Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

ANNEX 14.2.

How E-Government Affects Governance (Sub-components)

The table below shows the regression results of subcomponents of institutional quality on sub-components of the EGDI, controlling for income level with the HDI. The data cover 131 countries in 2003, 2004, 2005, 2008, 2010, 2012, 2014, 2016, and 2018.

ANNEX TABLE 14.2.1.

E-Government Indicators as Potential Determinants of Select Dimensions of Institutional Quality							
Variables	(1) Government Effectiveness	(2) Control of Corruption	(3) Ease of Doing Business Index	(4) Political Stability	(5) Regulatory Quality	(6) Rule of Law	(7) Voice and Accountability
Human Capital Index	1.349*** (0.127)	1.238*** (0.164)	1.526*** (0.206)	0.876*** (0.182)	1.225*** (0.123)	1.119*** (0.141)	1.568*** (0.174)
Online Service Index	0.255*** (0.0870)	-0.00552 (0.112)	0.626*** (0.135)	-0.962*** (0.125)	0.354*** (0.0845)	-0.00527 (0.0968)	0.0381 (0.119)
Telecommunication Infrastructure Index	2.311*** (0.118)	2.971*** (0.152)	0.997*** (0.192)	2.247*** (0.169)	1.829*** (0.115)	2.678*** (0.131)	1.939*** (0.161)
Human Development Index	-0.0107 (0.230)	-0.659** (0.296)	-0.350 (0.395)	0.494 (0.329)	0.346 (0.224)	-0.157 (0.256)	-0.578* (0.314)
Constant	-1.648*** (0.0860)	-1.266*** (0.111)	-1.281*** (0.143)	-1.274*** (0.123)	-1.668*** (0.0836)	-1.433*** (0.0957)	-1.255*** (0.118)
Observations	1,157	1,157	1,040	1,157	1,157	1,157	1,157
R-squared	0.751	0.643	0.401	0.432	0.732	0.699	0.492

Sources: United Nations Development Program, Human Development Index; UN e-government databases; and World Bank Group, Worldwide Governance Indicator.

Note: Standard errors in parentheses, *** p < 0.01, ** p < 0.05, * p < 0.1

ANNEX 14.3.

Panel Data Estimation of the Correlations of E-Government and Governance

The table below shows the panel regression of control of corruption and government effectiveness on subcomponents of the EGDI and the HDI to capture the level of economic development.²⁸

ANNEX TABLE 14.3.1.

Panel Data Regressions of Governance Dimensions on E-Government Indicators				
Variables	Fixed Effect		Random Effect	
	Control of Corruption	Government Effectiveness	Control of Corruption	Government Effectiveness
Telecommunication Infrastructure Index	−0.193 (0.124)	0.229 (0.133)	0.221*** (0.0515)	0.690*** (0.0744)
Human Capital Index	−0.0674 (0.202)	0.166 (0.167)	0.812** (0.386)	1.194*** (0.343)
Online Service Index	0.159 (0.0974)	0.0553 (0.101)	0.150 (0.115)	0.0645 (0.137)
Human Development Index	0.0573 (0.307)	−0.0453 (0.181)	0.603 (0.690)	0.614 (0.654)
Constant	0.129 (0.0879)	0.0122 (0.0942)	−1.051*** (0.339)	−1.385*** (0.407)
Observations	1,157	1,157	1,157	1,157
R-squared	0.199	0.748	0.528	0.701
Number of Country	130	130	130	130

Sources: World Bank Group, Worldwide Governance Indicator; United Nations Development Program, Human Development Index; and United Nations e-government databases.

Note: Robust standard errors in parentheses, with cluster of income groups; *** p<0.01, ** p<0.05, * p<0.1.

ANNEX 14.4.

Granger Causality Results

The table below presents the underlying results for Figure 14.9, the Granger causality matrix. Please note that the subtable on the top shows the result of whether the variable WGI Granger causes the variable E-Government Index (EGOV), whereas the bottom subtable shows the result of whether the variable EGDI Granger causes the variable WGI. If “Yes” is shown in the last row, the Granger cause relationship exists between the two variables for at least one country.

²⁸ Obviously, beyond e-government, other factors influence governance. The economic literature has categorized corruption factors into four groups: economic factors, political and governmental factors, demographic factors, and cultural factors. The effects of all these factors, which should be used for a more comprehensive governance model, are assumed to be in the residual of the regression as omitted variables. This also represents a source of bias for the estimates.

ANNEX TABLE 14.4.1.

Granger Causality Test Result (Institutional Quality to E-Government)														
WGI => EGDI	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	E-Government Development Index							Telecommunication Infrastructure Index						
Institutional Quality	0.306 (0.278)							0.580* (0.243)						
Voice and Accountability		0.211 (0.186)							0.389* (0.177)					
Rule of Law			0.0605 (0.196)							0.188 (0.214)				
Regulatory Quality				0.240 (0.320)							0.0332 (0.412)			
Political Stability					-0.0415 (0.194)							0.0388 (0.209)		
Government Effectiveness						0.145 (0.197)							0.273 (0.206)	
Control of Corruption							0.141 (0.129)							0.267* (0.104)
zbart_pv	0.763	0.826	0.4	0.0621	0.152	0.504	0.893	0.341	0.542	0.247	0.0749	0.00179	0.0165	0.22
	No	No	No	No	No	No	No	No	No	No	No	Yes	Yes	No

WGI => EGD	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	Human Capital Index							Online Service Index						
Institutional Quality	−0.356*							0.778						
	(0.146)							(0.679)						
Voice and Accountability		−0.185							0.453					
		(0.141)							(0.495)					
Rule of Law			−0.161							0.162				
			(0.155)							(0.536)				
Regulatory Quality				−0.418*							1.110			
				(0.165)							(0.653)			
Political Stability					0.00202							−0.0203		
					(0.165)							(0.560)		
Government Effectiveness						−0.0931							0.231	
						(0.182)							(0.571)	
Control of Corruption							−0.146							0.339
							(0.0832)							(0.342)
zbart_pv	0.377	0.501	0.0000602	0.00177	0.35	0.00358	6.38E-09	0.921	0.894	0.108	0.0575	0.122	0.892	0.751
	No	No	Yes	Yes	No	Yes	Yes	No	No	No	No	No	No	No

ANNEX TABLE 14.4.2.

Granger Causality Test Result (E-Government to Institutional Quality)														
EGDI => WGI	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	Institutional Quality	Voice and Accountability	Rule of Law	Regulatory Quality	Political Stability	Government Effectiveness	Control of Corruption	Institutional Quality	Voice and Accountability	Rule of Law	Regulatory Quality	Political Stability	Government Effectiveness	Control of Corruption
E-Government Development Index	0.429 (0.489)	0.853 (0.551)	0.432 (0.527)	1.446** (0.539)	2.038** (0.643)	0.621 (0.411)	−0.0494 (0.820)							
Telecommunication Infrastructure Index								0.113 (0.287)	0.361 (0.351)	0.178 (0.305)	0.847** (0.322)	0.908* (0.416)	0.241 (0.255)	−0.144 (0.431)
Human Capital Index														
Online Service Index														
Constant	0.235 (0.221)	0.193 (0.320)	0.341 (0.321)	−0.279 (0.201)	−0.180 (0.239)	0.211 (0.278)	0.463 (0.403)	0.344 (0.275)	0.498 (0.410)	0.520* (0.258)	0.328** (0.113)	0.565* (0.254)	0.490* (0.214)	0.403 (0.396)
zbart_pv	0.00186	0.00276	0.282	0.607	0.557	0.0652	0.0913	6E-08	4E-02	5E-11	6E-04	1E-02	2E-03	2E-04
	Yes	Yes	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes

EGDI => WGI	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Variables	Institutional Quality	Voice and Accountability	Rule of Law	Regulatory Quality	Political Stability	Government Effectiveness	Control of Corruption	Institutional Quality	Voice and Accountability	Rule of Law	Regulatory Quality	Political Stability	Government Effectiveness	Control of Corruption
E-Government Development Index														
Telecommunication Infrastructure Index														
Human Capital Index	−0.0104 (0.537)	−0.578 (0.724)	−0.0516 (0.708)	−0.604 (0.868)	−1.779 (1.129)	−0.530 (0.607)	0.591 (0.841)							
Online Service Index								0.186 (0.219)	0.412 (0.251)	0.188 (0.265)	0.472 (0.304)	1.058** (0.337)	0.359 (0.193)	−0.0317 (0.386)
Constant	0.295 (0.656)	0.956 (0.926)	0.559 (0.761)	0.845 (0.952)	2.368 (1.331)	1.018 (0.613)	−0.183 (0.972)	0.333 (0.223)	0.389 (0.317)	0.466 (0.259)	0.164 (0.128)	0.474* (0.190)	0.367 (0.195)	0.449 (0.373)
zbart_pv	4E-05	9E-01	2E-03	3E-02	3E-04	2E-07	3E-04	0.351	0.0917	0.487	0.629	0.903	0.553	0.0228
	Yes	No	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No	Yes

Sources: Luciano and Sylvain (2017); United Nations E-Government Development Index; United Nations Development Program, Human Development Index; and World Bank Group, Worldwide Governance Indicator.

Note: Standard errors in parentheses; *** p < 0.01, ** p < 0.05, * p < 0.1.

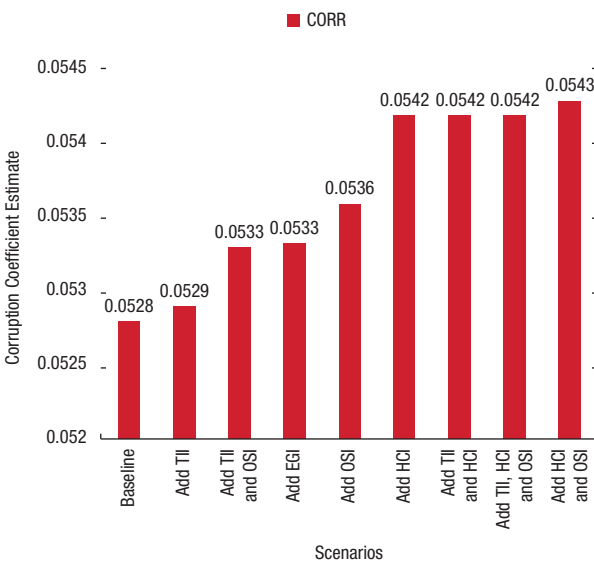
ANNEX 14.5.

Innovation, Governance, and Revenue

Annex Table 14.5.1 shows the regression results between government revenue (in percent of GDP) and institutional quality and e-government, controlling for the level of development via HDI. Annex Figure 14.5.2 shows the changes in the control of corruption coefficient in the regression as we add subcomponents of e-government to look at the reduction in bias in the original coefficient estimate.

ANNEX TABLE 14.5.1.

ANNEX FIGURE 14.5.1.

Potential impact of institutional quality and e-government on government revenue		Changes in Control of Corruption Coefficient under Different Scenarios	
Variables			
Government Effectiveness	0.0293** (0.0119)		
Control of Corruption	0.0542*** (0.00962)		
Ease of Doing Business Index	0.00358 (0.00392)		
Political Stability	-0.000291 (0.00473)		
Regulatory Quality	-0.0353*** (0.00941)		
Rule of Law	-0.0711*** (0.0128)		
Voice and Accountability	0.0480*** (0.00472)		
Human Development Index	-0.00163 (0.0479)		
Telecommunication Infrastructure Index	0.0719*** (0.0263)		
Human Capital Index	0.0698*** (0.0262)		
Online Service Index	-0.0404** (0.0171)		
Constant	0.116*** (0.0208)		
Observations	1,032		
R-squared	0.281		

Sources: United Nations Development Program, Human Development Index; United Nations E-Government Development Index; and World Bank Group, Worldwide Governance Indicator.

Note: Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. The benchmark coefficient is generated from regression with only the subcomponents of government revenue and institutional quality. The other scenarios are generated to compare the addition effects of e-government components to the effect of control of corruption in government revenue.

ANNEX 14.6.

Interaction Effects

Annex Table 14.6.1 adds the interaction effect between control of corruption and the e-government subindicators (HCI, OST, and TII) to the model.

ANNEX TABLE 14.6.1.

Interacting e-government and control of corruption (Percent of GDP)		
	(1)	(2)
Variables	Government Revenue	Government Revenue
Control of Corruption	-0.0138 (0.0147)	-0.0196 (0.0155)
Rule of Law	-0.0297*** (0.00954)	-0.0290*** (0.00950)
Voice and Accountability	0.00901 (0.00565)	0.00910 (0.00576)
Regulatory Quality	0.00936 (0.00896)	0.00913 (0.00885)
Political Stability	0.00553 (0.00365)	0.00600 (0.00372)
Human Development Index	0.0913** (0.0409)	0.0828** (0.0337)
Control of Corruption * Human Capital Index	0.0448** (0.0181)	0.0520*** (0.0194)
Control of Corruption * Telecommunication Infrastructure Index	0.0487 (0.0449)	0.0773* (0.0413)
Control of Corruption * Telecommunication Infrastructure Index * Human Capital Index	-0.0876* (0.0524)	-0.106** (0.0518)
Control of Corruption * Telecommunication Infrastructure Index * Online Service Index	0.0165* (0.00984)	
Constant	0.105*** (0.0289)	0.111*** (0.0238)
Observations	1,157	1,166
R-squared	0.072	0.068
Number of Country	130	130
R-squared	0.166	0.168

Sources: United Nations Development Program, Human Development Index; United Nations E-Government Development Index; and World Bank Group, Worldwide Governance Indicator.

Note: Robust standard error; *** p<0.01, ** p<0.05, * p<0.1.

ANNEX TABLE 14.6.2.

Interaction Effects, By Region (Percent of GDP)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Government Revenue	Government Revenue	Government Revenue	Government Revenue	Government Revenue	Government Revenue	Government Revenue
East Asia and Pacific							
Control of Corruption * Human Capital Index	0.0665			0.0780	0.0341		−0.136
Control of Corruption * Online Service Index		−0.0411		−0.0313		−0.0220	−0.0666
Control of Corruption * Telecommunication Infrastructure Index			−0.0529*		−0.0430	−0.0328	−0.0133
Europe and Central Asia							
Control of Corruption * Human Capital Index	−0.0322			−0.0135	0.0578		0.0296
Control of Corruption * Online Service Index		0.0352*		0.0327		0.0155	0.0159
Control of Corruption * Telecommunication Infrastructure Index			0.0506		0.0720*	0.0393	0.0499
Sub-Saharan Africa							
Control of Corruption * Human Capital Index	0.0437			0.0423	0.0713***		0.0652***
Control of Corruption * Online Service Index		0.00209		0.0107		−0.0175	−0.0137
Control of Corruption * Telecommunication Infrastructure Index			0.0368		0.0826	0.0608	0.0903

Middle East and North Africa

Control of Corruption * Human Capital Index	0.0640		0.174*	0.148*	0.277***
Control of Corruption * Online Service Index		0.0824***	0.0941***		0.0706**
Control of Corruption * Telecommunication Infrastructure Index			0.0417	0.0738***	0.0774
					0.115*

Latin America and Caribbean

Control of Corruption * Human Capital Index	0.0670***		0.0314	0.0219	0.0107
Control of Corruption * Online Service Index		-0.0193**	-0.0132		0.00819
Control of Corruption * Telecommunication Infrastructure Index			-0.0563***	-0.0503***	-0.0493**
					-0.0472*

High Income: OECD

Control of Corruption * Human Capital Index	-0.00830		-0.00569	-0.0109	-0.00845
Control of Corruption * Online Service Index		0.00296	0.00246		0.00346
Control of Corruption * Telecommunication Infrastructure Index			-0.00123	-0.00335	-0.00317
					-0.00445

South Asia

Control of Corruption * Human Capital Index	0.212***		0.211***	0.200***	0.203***
Control of Corruption * Online Service Index		-0.0589	-0.0583*		-0.0257
Control of Corruption * Telecommunication Infrastructure Index			-0.138*	-0.128	-0.105
					-0.0894

Sources: United Nations Development Program, Human Development Index; United Nations E-Government Development Index; and World Bank Group, Worldwide Governance Indicator.

Note: Robust standard error; *** p<0.01, ** p<0.05, * p<0.1.

ANNEX 14.7.

Transmission Effect with Instrumental Variables

The instrumental variables—the e-government subindicators (HCI, TII, and OSI)—are used as additional variables to estimate the causal effect of corruption on revenue. These variables qualify as instrumental (relative to the pair consisting of control of corruption and revenue) because (1) they are independent of all variables (including error terms) that have an influence on revenue that is not mediated by corruption (exclusion restriction), (2) they are not independent of corruption, and (3) there is no confounding for the effect of e-government on revenue. Therefore, these e-government instrumental variables affect revenue only through their effects on corruption. Consequently, the e-government indicators are unrelated to revenue but are related to the predictor of revenue (corruption) and are not causally affected (directly or indirectly) by corruption, revenue, or the error term from the regression of revenue on corruption.

In Annex Table 14.7.1, a baseline regression of revenue on corruption and other institutional quality variables is run before adding the three e-government subindicators as the instrumental variables. The purpose is to see how the coefficient of control of corruption would change when different instrumental variables are added to the model.

ANNEX TABLE 14.7.1.

Transmission Effects with Instrumental Variables
(Percent of GDP)

	(0) Baseline	(1) Instrumental Variable: HCI	(2) Instrumental Variable: TII	(3) Instrumental Variable: HCI TII	(4) Instrumental Variable: HCI TII OSI
Variables	Government Revenue	Government Revenue	Government Revenue	Government Revenue	Government Revenue
Control of Corruption	0.0157** (0.00643)	−0.451 (0.586)	−0.312 (0.406)	−0.368 (0.420)	0.0484 (0.0713)
Rule of Law	−0.0279*** (0.00983)	0.133 (0.196)	0.0849 (0.137)	0.104 (0.140)	−0.0403 (0.0283)
Voice and Accountability	0.0108* (0.00571)	0.114 (0.134)	0.0829 (0.0910)	0.0954 (0.0962)	0.00180 (0.0170)
Regulatory Quality	0.0108 (0.00883)	0.138 (0.160)	0.101 (0.110)	0.115 (0.114)	0.00168 (0.0190)
Political Stability	0.00631* (0.00377)	−0.00471 (0.0166)	−0.00110 (0.0112)	−0.00291 (0.0123)	0.00597 (0.00422)
Human Development Index	0.0857** (0.0348)	−0.0270 (0.149)	0.00694 (0.107)	−0.00761 (0.110)	0.104** (0.0482)
Constant	0.108*** (0.0244)	0.182* (0.100)	0.159** (0.0717)	0.169** (0.0745)	0.0966*** (0.0336)
Observations	1,170	1,167	1,169	1,166	1,158
Number of country	130	130	130	130	130
R-squared	0.204	0.0675	0.0580	0.0639	0.0961

Sources: United Nations Development Program, Human Development Index; United Nations E-Government Development Index; and World Bank Group, Worldwide Governance Indicator.

Note: HCI = Human Capital Index; OSI = Online Service Index; TII = Telecommunication Infrastructure Index.

Robust standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

ANNEX 14.8.

Regional Groupings

ANNEX TABLE 14.8.1.

Regional Groupings, Countries List						
South Asia	Europe and Central Asia	Middle East and North Africa	Sub-Saharan Africa	Latin America and Caribbean	High Income: OECD	East Asia and Pacific
Afghanistan	Albania	Algeria	Angola	Antigua and Barbuda	Australia	Brunei Darussalam
Bangladesh	Armenia	Bahrain	Benin	Argentina	Austria	Cambodia
Bangladesh Chittagong	Azerbaijan	Djibouti	Botswana	Bahamas, The	Belgium	China
Bangladesh Dhaka	Belarus	Egypt, Arab Rep.	Burkina Faso	Barbados	Canada	China Beijing
Bhutan	Bosnia and Herzegovina	Iran, Islamic Rep.	Burundi	Belize	Chile	China Shanghai
India	Bulgaria	Iraq	Cabo Verde	Bolivia	Czech Republic	Fiji
India Delhi	Croatia	Jordan	Cameroon	Brazil	Denmark	Hong Kong SAR, China
India Mumbai	Cyprus	Kuwait	Central African Republic	Brazil Rio de Janeiro	Estonia	Indonesia
Maldives	Georgia	Lebanon	Chad	Brazil São Paulo	Finland	Indonesia Jakarta
Nepal	Kazakhstan	Libya	Comoros	Colombia	France	Indonesia Surabaya
Pakistan	Kosovo	Malta	Congo, Dem. Rep.	Costa Rica	Germany	Kiribati
Pakistan Karachi	Kyrgyz Republic	Morocco	Congo, Rep.	Dominica	Greece	Lao PDR
Pakistan Lahore	Liechtenstein	Oman	Côte d'Ivoire	Dominican Republic	Hungary	Malaysia
Sri Lanka	Moldova	Qatar	Equatorial Guinea	Ecuador	Iceland	Marshall Islands

Montenegro	Saudi Arabia	Eritrea	El Salvador	Ireland	Micronesia, Fed. Sts.
North Macedonia	Syrian Arab Republic	Eswatini	Grenada	Israel	Mongolia
Romania	Tunisia	Ethiopia	Guatemala	Italy	Myanmar
Russian Federation	United Arab Emirates	Gabon	Guyana	Japan	Palau
Russian Federation Moscow	West Bank and Gaza	Gambia, The	Haiti	Japan Osaka	Papua New Guinea
Russian Federation Saint Petersburg	Yemen, Rep.	Ghana	Honduras	Japan Tokyo	Philippines
San Marino	Iran	Guinea	Jamaica	Korea, Rep.	Samoa
Serbia	Palestine	Guinea-Bissau	Mexico	Latvia	Singapore
Tajikistan		Kenya	Mexico Mexico City	Lithuania	Solomon Islands
Turkey		Lesotho	Mexico Monterrey	Luxembourg	Taiwan, China
Ukraine		Liberia	Nicaragua	Netherlands	Thailand
Uzbekistan		Madagascar	Panama	New Zealand	Timor-Leste
Andorra		Malawi	Paraguay	Norway	Tonga
Kyrgyzstan		Mali	Peru	Poland	Vanuatu
Monaco		Mauritania	Puerto Rico	Portugal	Vietnam
Turkmenistan		Mauritius	St. Kitts and Nevis	Slovak Republic	Korea, Dem. People's Rep.
Greenland		Mozambique	St. Lucia	Slovenia	Nauru
Jersey, Channel Islands		Namibia	St. Vincent and the Grenadines	Spain	Tuvalu
Gibraltar		Niger	Suriname	Sweden	American Samoa
Isle of Man		Nigeria	Trinidad and Tobago	Switzerland	Cook Islands
Serbia and Montenegro		Nigeria Kano	Uruguay	United Kingdom	Guam
Yugoslavia		Nigeria Lagos	Venezuela, RB	United States	Macao SAR, China

(continued)

ANNEX TABLE 14.8.1. (CONTINUED)

South Asia	Europe and Central Asia	Middle East and North Africa	Sub-Saharan Africa	Latin America and Caribbean	High Income: OECD	East Asia and Pacific
	Faroe Islands		Rwanda	Cuba	United States Los Angeles	Niue
			São Tomé and Príncipe	Anguilla	United States New York City	Taiwan Province of China
			Senegal	Aruba		French Polynesia
			Seychelles	Bermuda		New Caledonia
			Sierra Leone	Cayman Islands		Northern Mariana Islands
			Somalia	French Guiana		Kribati
			South Africa	Martinique		
			South Sudan	Netherlands Antilles		
			Sudan	Virgin Islands (U.S.)		
			Tanzania	Curacao		
			Togo	Sint Maarten (Dutch part)		
			Uganda	St. Martin (French part)		
			Zambia	Turks and Caicos Islands		
			Zimbabwe			
			Sao Tome and Principe			
			Reunion			
			Swaziland			
			Congo-Brazzaville			

Source: International Monetary Fund, World Economic Outlook.

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