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Transforming Public Finance through GovTech

Prepared by David Amaglobeli, Ruud de Mooij, Andualem Mengistu, Mariano Moszoro, Manabu Nose, Soheib Nunhuck, Sailendra Pattanayak, Lorena Rivero del Paso, Frankosiligi Solomon, Rebecca Sparkman, Herve Tourpe, and Gerardo Uña

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ABSTRACT: A digital divide across and within countries continues to persist and has even increased when the quality of internet connection is taken into account. This note shows that many governments have not been able to harness the full potential of digitalization. Governments could play an important role in facilitating digital adoption by intervening both on the supply side (investing in infrastructure) and the demand side (increase internet affordability). This note also documents significant dividends from digital adoption for revenue collection and spending efficiency and for outcomes in education, health, and social safety nets. The note emphasizes that digitalization is not a substitute for good governance and that comprehensive reform plans embedded in national digital strategies, combined with legal and institutional reforms, are needed to ensure that governments can reap the full benefits of digitalization and manage the risks appropriately.

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Abbreviations and Acronyms

AE	Advanced Economy
API	Application Programmatic Interface
CCA	Caucasus and Central Asia
CD	Capacity Development
CIT	Corporate Income Tax
COVID-19	Coronavirus Disease of 2019
DPI	Digital Public Infrastructure
ED-Asia	Emerging and Developing Asia
ED-Europe	Emerging and Developing Europe
EMDE	Emerging Market and Developing Economy
EME	Emerging Market Economy
FMIS	Financial Management Information System
GovTech	Government Technology
ISORA	International Survey on Revenue Administration
LAC	Latin America and the Caribbean
LIDC	Low-Income Developing Country
MENAP	Middle East, North Africa, and Pakistan
ML	Machine Learning
NLP	Natural Language Processing
PFM	Public Financial Management
PIMS	Public Investment Management System
PIT	Personal Income Tax
RPA	Robotic Process Automation
SSA	Sub-Saharan Africa
SSN	Social Safety Net
TADAT	Tax Administration Diagnostic Assessment Tool
TSA	Treasury Single Account
VAT	Value-Added Tax

Executive Summary

Universal internet connectivity remains an elusive target as many governments forgo opportunities to unleash the transformative force of digitalization. About 3 billion people globally are not connected to the internet. Emerging market and developing economies are considerably behind advanced economies. Within countries, the digital divide is most pronounced across gender and age. For example, in low-income developing countries even women with tertiary education are less likely to own a mobile phone—a proxy for digital adoption—than men with less than primary education. In public finance, progress in the use of government technology—or "GovTech"—has been uneven across countries. Many governments are not yet able to fully use the potential of digital technologies to deliver public services and improve operations. For example, only half of low-income developing countries allow taxpayers to register online, and despite progress in the rollout of treasury single account IT systems, large gaps in coverage and the extent of adoption are common.

This note discusses the significant potential of digitalization with a particular focus on public finance. The note looks at the role of government policies in tackling the widening digital divide, documents large social dividends from GovTech adoption in public finance and provides advice on how to plan and manage the implementation of GovTech solutions in public finance while maximizing benefits and minimizing risks.

According to IMF estimates, $418 billion in (public and private) investment is necessary to bring connectivity to unconnected households globally (Oughton, Amaglobeli, and Moszoro 2023). On average, this equals 3.5 percent of GDP in low-income developing countries and 0.7 percent of GDP in emerging market economies. Through direct interventions, governments can support efforts to achieve universal connectivity faster. Both supply- and demand-side policies should be considered. Incentivizing investment or directly investing in digital infrastructure is one such intervention. On the demand side, allaying concerns about internet affordability (for example, via discounts on service fees) and supporting digital literacy can facilitate digital adoption.

Digital adoption by governments has the potential to strengthen public finance operations and improve the delivery of basic services. GovTech solutions in revenue administration can enhance revenue collection significantly. Automating budget payments can improve the quality of budget management and adopting an e-procurement platform can boost fiscal transparency. Digitalization is also associated with improving expenditure efficiency in health and education. An increase in internet use from 10 to 90 percent is associated with a rise in average primary and secondary education scores of up to 25 percent. In health care, GovTech can improve quality, increase population coverage, and reduce spending inefficiencies. Adopting digital technologies for Treasury payments could help expand the coverage of social assistance programs for the extremely poor by 7 percent.

Governments can reap the benefits of digitalization with proper consideration for the necessary prerequisites. Comprehensive reform plans embedded in national digital strategies can help achieve economy-wide digital adoption while taking into account the current stage of digitalization maturity. Successful implementation of digital solutions for public finance requires that users make full use of functional capabilities of the information system and that necessary legal and institutional reforms are appropriately designed and executed. Effective safeguards for data security, privacy, and assurance of resilience in digital solutions, including cyber risk aspects, must be in place to maintain trust and promote adoption. By prioritizing citizen-centric design principles and engaging in close collaboration with stakeholders, GovTech can help overcome these challenges and unlock its full potential to enhance public services for society.

I. Introduction

Digital technologies are transforming societies in much the same way as previous major breakthroughs in communication and transportation. In the 19th century, the emergence of railways revolutionized transportation by making it possible to transport goods and people more quickly and efficiently, which enabled the development of new industries, such as mass manufacturing and distribution. The advent of highways in the 20th century increased the efficiency of transportation by facilitating faster and more efficient delivery of goods and information (for example, books and newspapers) and improved the response of emergency services. While railways and highways are physical transportation infrastructure, and the internet is digital communication infrastructure, they have several similarities in their impact on society. They have also had significant social and political implications, including changes in the way we interact with each other and the way we organize our societies (Silve and Moszoro 2023).

To make full use of digital communication, connecting households to the internet is essential. Unfortunately, hundreds of millions of households around the world are still unconnected. This digital divide can have significant social and economic consequences, as it can limit access to education, health care, job opportunities, and other essential services. Overall, connecting unconnected households is a critical step in ensuring that everyone can benefit from digital communication and participate fully in the digital economy. In addition, to reap full benefits from ongoing digitalization, it is essential to accelerate and strengthen the adoption of digital solutions in the public sector.

Digitalization of government services, known as "GovTech," is an opportunity to transform the public sector.[1] Already deployed solutions include digital platforms (for example, cloud storage, payment processes, digital identification); internal systems (for example, digitalization of revenue administration, public financial management, data sharing between administrations); and government-user interfaces (for example, online submission of fiscal declarations, centralized medical records). GovTech initiatives transform the relationship between citizens, businesses, and the state, making the government more efficient, transparent, and agile. It changes the services that citizens expect from the state (Dener and others 2021) and the state's accountability to its citizens, thanks to better information for the population. GovTech must be inclusive, which implies limiting the sector's scope and keeping more traditional supplies of public services open to citizens who find themselves on the wrong side of the digital divide (Silve and Moszoro 2023). Digitalization can help streamline the inclusive provision of public services.

This note discusses the two-way relationship between digitalization and public finance. The pace of digitalization has accelerated in recent years, particularly since the COVID-19 pandemic, which warrants revisiting the IMF's earlier work on digitalization in public finance (Gupta and others 2017). This note (1) presents digitalization trends and documents a large digital divide that denies billions of people the opportunity to reap the benefits of digitalization; (2) discusses how digital technologies transform the role of government in policy and operations; (3) provides evidence of substantial economic and social dividends from digital adoption; (4) estimates how the use of digital technologies in public finance improves revenue collection, spending efficiency, fiscal transparency, and public services delivery; and (5) discusses the role of government policies in fostering digital adoption in fiscal operations, considering cyber risks and privacy concerns.

[1] For a more detailed definition of GovTech and other key digitalization terms used in this note, please refer to Annex I.

II. Trends in Digitalization

A. Digital Divide

Unleashing the transformative power of digitalization requires that households, firms, and governments embrace new technologies. Digitalization is the use of technologies in a way that fully automates information flow, leading to a fundamental change in the way traditional processes are conducted. Achieving this state calls for acceleration in the process through which digital technologies are used by households and companies to their full potential—also known as "digital adoption." Internet adoption, a particular form of digital adoption, refers to the process that allows people to securely access the internet daily through their personal devices and to perform common tasks, such as access online services, use social media, and communicate with others. The extent of digital adoption can vary depending on the extent to which the functionality provided by digital solutions is being used. For example, cell phones without internet connectivity are a form of digitalization but with more limited functionality than cell phones with internet.

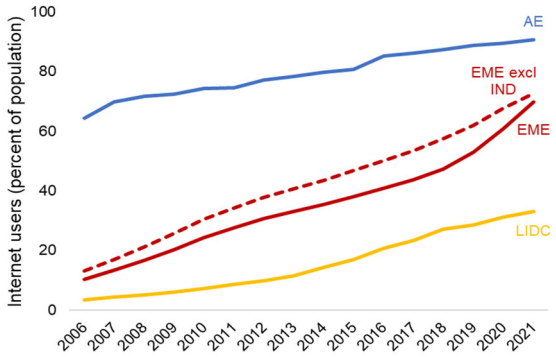
Digital adoption by households, firms, and governments is transforming societies. Digital technologies are instrumental in lowering economic costs related to search, replication, transportation, tracking, and verification (Goldfarb and Tucker 2019). By lowering the cost of searching for information, such as product prices and job vacancies, digital technologies have the potential to reduce prices, expand the variety of products, and increase the quality of matches between firms and consumers or employers and employees. The reduction in replication costs, for example, allows consumers and workers in emerging market and developing economies access to the same information as people in advanced economies. Lower transportation costs (for example, through optimization of routes and logistics, enhanced fleet management, and demand forecasting and inventory management) suggest that consumers in remote areas could access the same digital products and services as everyone else. Reductions in tracking and verification (of identity) costs are allowing producers to closely tailor their products to individual consumers. Access to vast amounts of data allows companies to employ artificial intelligence (AI) to boost efficiency through automation of processes, to make more informed decisions, and to identify opportunities for creation of new products and services.

Despite progress over several years, achieving universal global digital adoption remains a distant prospect. Internet access, which is the necessary condition for digital adoption, is uneven across and within countries.[2] Nearly 3 billion people worldwide do not use the internet; another 2 billion are poorly connected, relying on 3G or slower mobile broadband. The cross-country variation in internet access is large. In advanced economies, 91 percent of people were using the internet in 2021 as opposed to 70 percent and 33 percent, respectively, in emerging market economies and low-income developing countries (Figure 1, panel 1). Internet access greatly lags internet coverage—the share of the population living within an area with a mobile signal—which suggests that affordability and lack of devices and skills may be preventing adoption (Figure 1, panel 2). While the adoption of 5G is expected to be the main driver of mobile technology development and faster broadband speed growth in the coming years, mobile device 5G subscriptions were small: there were about 160 million in 2020 (Figure 1, panel 3).

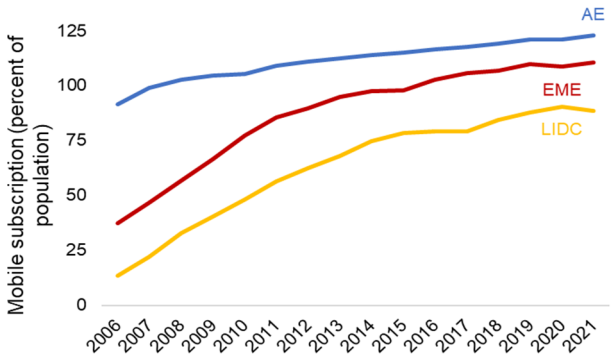
[2] This note defines digital adoption as the process of integrating internet-based digital technologies into a household's or an organization's daily activities and operations.

Figure 1. Developments in Internet Access

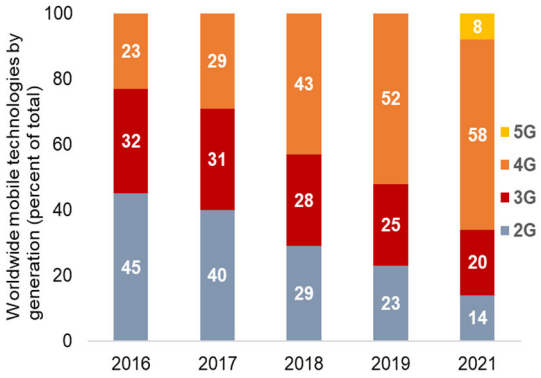
1. Internet Users (Percent of population)



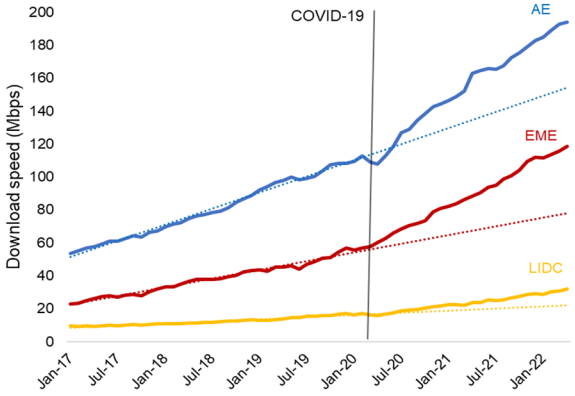
2. Mobile Cellular Subscriptions (Percent of population)



3. Worldwide Mobile Technologies by Generation (Percent of total)



4. Internet Download Speed (Megabits per second)



Sources: Amaglobeli and others (2023); Ericsson; GSMA Intelligence; International Telecommunications Union; Ookla; and Statista.
Note: Population-weighted average is used. Download speed is the fixed band average download speed. Trend lines in panel 4 are based on pre-pandemic developments, and the gray line refers to March 2020, when the World Health Organization declared COVID-19 a global pandemic. The dotted line in panel 4 is the fitted trend line without a structural break. AE = advanced economy; EME = emerging market economy; IND = India; LIDC = low-income developing country.

Internet use accelerated during COVID-19 at the intensive margin (proxy for the quality of connection) but not at the extensive margin (the coverage of population) (Amaglobeli and others 2023). Annual growth of internet users accelerated only in emerging market economies during COVID-19, driven mainly by the rapid surge of internet use in India, which had started before the outbreak of the pandemic.[3] Internet use in advanced economies and low-income developing countries has remained at the historical trend since the outbreak of COVID-19.[4] However, improved speed is noted among existing users.[5] The average download/upload speed since the outbreak of COVID-19 accelerated considerably across all income groups

[3] India launched the "Digital India" campaign in 2015 targeting faster and more inclusive economic growth by pushing government and banking services online and by investing in technology.

[4] In 2015–16, internet users per 100 people in the US grew from 74.5 to 85.5, leading to a spike in internet coverage in advanced economies in 2016.

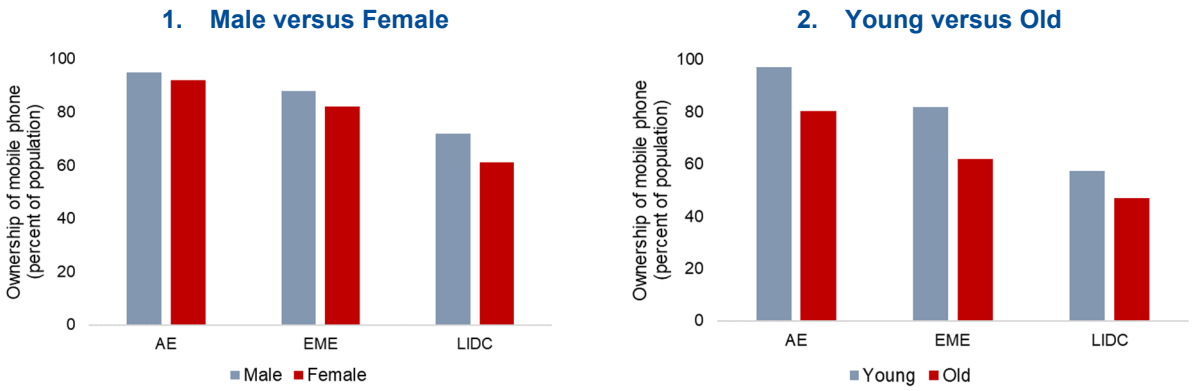
[5] Ookla Speedtest Intelligence® data provides aggregated measurements on internet performance collected through Speedtest®, a web and app consumer-initiated testing tool. See Amaglobeli and others (2023) for details.

(Figure 1 panel 4). This probably reflects the fact that existing internet users started to upgrade their internet packages as most work- and household-related activities shifted online.

Digital adoption differs considerably within countries. Mobile ownership (a widely available proxy for digital adoption) for women and for the elderly is significantly lower for all country income groups (Figure 2). Cross-country individual-level analysis shows that keeping labor force participation, income, education, and age constant, women are significantly less likely to own mobile phones than men (Kumar, Amaglobeli, and Moszoro 2023).[6] In low-income developing countries, for example, less-than-primary-educated women are 10 percent less likely to own a mobile phone than men with comparable education. Even women with tertiary education are 1.2 percent less likely to own a mobile phone than less-than-primary-educated men. These differences hold for emerging market and advanced economies but are smaller. Moreover, the elderly (those over age 65) across the world are less likely to own mobile phones than teenagers (those younger than age 20) even after taking into account gender, education, and income.

Figure 2. Digital Divide by Gender and Age

(Percent of the population owning a mobile phone)

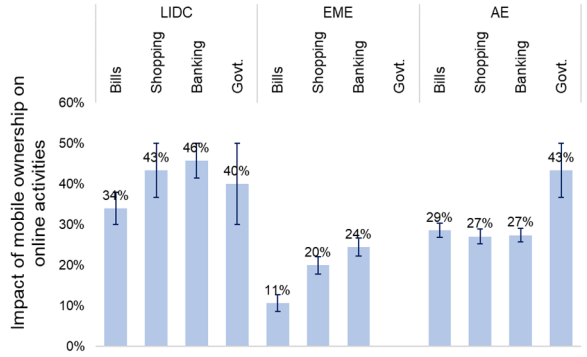


Sources: Kumar, Amaglobeli, and Moszoro (2023) based on World Bank FINDEX survey of more than 150 countries in 2017.
Note: The charts plot simple averages of mobile ownership by country income groups. AE = advanced economy; EME = emerging market economy; LIDC = low-income developing country.

Gaps in internet access lead to large cross- and within-country variations in digital adoption. The analysis of cross-country individual-level data shows that mobile phone ownership is positively and significantly associated with various internet-based activities, such as online bill payment, shopping, banking, and the receipt of government transfers (Figure 3). These results hold true for all country income groups. For example, mobile phone owners in low-income developing countries are 34 percent more likely than the national average to pay bills online and approximately 40 percent more likely than the national average to shop and bank online or receive government transfers using a phone.

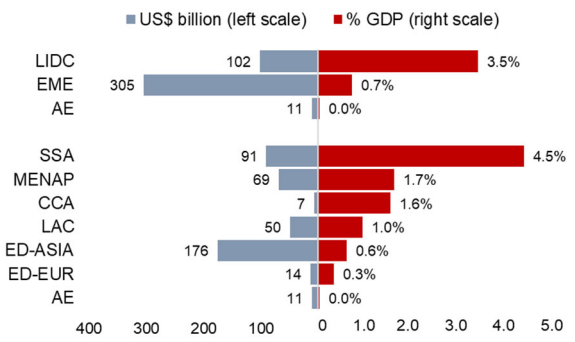
[6] The analysis uses microdata from the World Bank FINDEX survey of more than 150 countries in 2017. The data samples approximately 1,000 individuals in each of the 150 countries and provides sampling weights. The effects of different demographic and socioeconomic characteristics on digital adoption are estimated using mobile phone ownership and measures for selected internet-based activities to proxy for overall level of digital adoption.

Figure 3. Estimated Impact of Mobile Phone Ownership on Online Activities



Source: Authors' calculations based on Kumar, Amaglobeli, and Moszoro (2023).
Note: The figure plots estimates and standard deviations of the probability of engaging in online activities conditional on mobile ownership. AE = advanced economy; EME = emerging market economy; LIDC = low-income developing country.

Figure 4. Digital Infrastructure Investment Needs



Source: Oughton, Amaglobeli, and Moszoro (2023).
Note: AE = advanced economy; CCA = Caucasus and Central Asia; ED-Asia = emerging and developing Asia; ED-EUR = emerging and developing Europe; EME = emerging market economy; LAC = Latin America and the Caribbean; LIDC = low-income developing country; MENAP = Middle East, North Africa, and Pakistan; SSA = sub-Saharan Africa.

B. Fostering Digital Adoption

To provide universal broadband connectivity, SDG 9.c, we estimate that the aggregate global digital infrastructure investment needs are $418 billion.[7] This estimate assumes providing universal 4G cellular broadband to users with approximately 40–50 gigabytes of monthly data. Overall, the most prominent needs are in emerging market economies, estimated at $305 billion, or 0.7 percent of GDP. In low-income developing countries, the total cost is $102 billion, or about 3.5 percent of GDP (Figure 4). Regarding geography, the largest needs are in sub-Saharan Africa, at 4.5 percent of GDP, followed by the Middle East, North Africa, and Pakistan, at 1.7 percent of GDP; the Caucasus and Central Asia, at 1.6 percent; and Latin America and the Caribbean, at 1 percent of GDP. The composition of required investments in low-income developing countries includes digital infrastructure capital expenditure, metro and backbone fiber, and infrastructure operational expenditure.

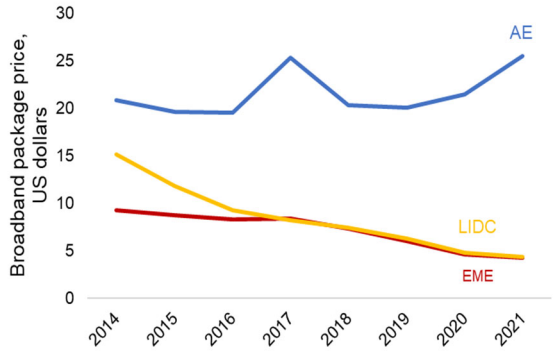
Digital adoption must also take into consideration affordability and digital literacy. Despite a continued decline in internet prices—a key factor for digital adoption—affordability remains a major concern, particularly in low-income developing countries. Nominal prices for a data-only mobile-broadband basket have dropped by more than half since 2015 to less than $5 a month in 2021 in emerging market economies and low-income developing countries (Figure 5, panel 1). However relative to per capita income the average mobile-broadband-basket price in 2020 was nine times higher in low-income developing countries than in advanced economies (Figure 5, panel 2). Such high relative prices make it more difficult for low-income developing countries to

[7] The estimate is based on Oughton, Amaglobeli, and Moszoro (2023), which evaluates investment requirements to achieve affordable universal broadband at the country level. The methodology relies on a geospatial model with population densities by decile and available infrastructure and assumes the deployment of the cheapest available technology (generally, 4G) to provide access.

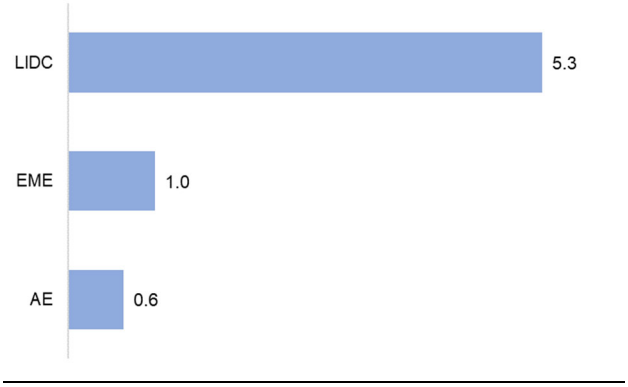
bridge the gap in internet access. Based on estimates from a model of demand for internet we find that demand is most price responsive in low-income developing countries and almost unresponsive in advanced economies (Kumar, Amaglobeli, and Moszoro 2023). Unfortunately, some poorer, less-educated communities may not always trust or know how to use these key technologies or may not have any proof of identity to access online secured services (Hasbi and Dubus 2020; Liu and Wang 2021). Digital infrastructure coverage, internet price, and usability (for example, the availability of applications in local languages) are found to be the most statistically robust predictors of internet use in the short term.

Figure 5. Mobile Broadband Prices

1. US Dollars a Month



2. Percent of Monthly GNI per Capita, 2020 (Percent)



Sources: Cable.co.uk (https://www.cable.co.uk/broadband/pricing/worldwide-comparison/); International Telecommunication Union; and IMF staff calculations.

Note: Information and communication technology prices are based on current and historical basket definitions in 2020 purchasing-power-parity US dollars and as a percent of monthly GNI per capita. Population-weighted average is used. AE = advanced economy; EME = emerging market economy; GNI = gross national income; LIDC = low-income developing country.

Fiscal policy, either on supply or demand, can help achieve faster digital adoption. While reforms that create business-friendly environments can be used to incentivize private sector investments in internet connectivity, fiscal policy can be deployed to provide direct policy interventions. On the supply side, such direct interventions aim at reducing the high entry cost in providing services through digital infrastructure to ensure universal access. Spending public funds may be necessary to support digital inclusion of people in remote and rural areas. On the demand side, policy interventions could include targeted price discounts for devices or subscription fees.[8] The interventions on both demand and supply could complement each other. For example, demand-side incentives could play a catalytic role for mobilizing private investments in broadband connectivity (Jeanjean 2010). The positive effect of demand-side policies increases with the degree of development of the broadband market, while the effect of supply-side policies can be more effective in terms of impact on internet subscriptions at the initial stages of development of the internet (Belloc, Nicita, and Rossi 2012).

Access to internet can be considered as part of basic needs, along with access to health care and education. In a sample of country experiences reviewed by the IMF staff, most programs focus on improving affordability by making internet cheaper, either by awarding private market players concessions and grants to

[8] Whereas price subsidies are generally known to be distortive, they might be helpful when pursuing certain social and economic objectives. For example, we expect positive network externalities from subsidizing internet subscriptions.

lower the cost of providing internet services or by issuing discount vouchers to consumers. The other priority is to improve the quality of internet services, that is, increase internet download and upload speed (See Annex II). For example, the US Affordable Connectivity Program gives eligible households a monthly discount on their internet bills and provides for significant infrastructure development toward expanding high-speed broadband. Cross-country studies show that public programs are a cost-efficient way to expand internet coverage and pay off through higher growth (Briglauer and Grajek 2021).

III. Dividends from GovTech

Digitalization has the potential to support government objectives of achieving higher and more stable economic growth. As digitalization allows for automation and streamlining of processes and repetitive tasks, it helps raise the economy's productivity and efficiency and generate growth dividends (Fabling and Grimes 2021; Qiang, Rossotto, and Kimura 2009; Appiah-Otoo and Song 2021; Koutroumpis 2009). The effect from the mobile broadband expansion is higher for lower-income countries (Edquist and others 2018). While digitalization can destroy some jobs, it can also create new tech-related sectors and positively affect job creation (Katz 2012). Higher digitalization mitigated disruptions from COVID-19, increasing aggregate productivity growth by a quarter and reducing the loss in hours worked by a third (Jaumotte and others 2023).

Digital adoption in public finance can improve efficiency and transparency of operations and the delivery of basic public services. Digitalization enables governments to leverage technology to enhance revenue mobilization, improve efficiency of public spending, strengthen fiscal transparency and accountability, and improve education and health service delivery and social outcomes. These can be achieved through better decision-making processes, promotion of adoption of international standards and practices, transformation of public financial management (PFM) processes and systems, and improved taxpayer and trader services to support voluntary compliance and trade facilitation. For example, during the COVID-19 pandemic, countries with digitalized PFM systems and tools could respond quickly and provide fiscal support to vulnerable households and businesses.

Like fintech, which changed the landscape of the financial sector, government technology, "GovTech," is emerging as a transformative force. GovTech refers to the way technology is used by government agencies and the private sector to transform government functions and provide citizens with better and citizen-centric access to public services. The term was inspired by the success of its financial counterpart—fintech. Several niche areas of government, such as education, supervision, regulations, and health care, have adopted their own terms, such as EdTech, SupTech, RegTech, and HealthTech. GovTech creates new opportunities to deploy digital technologies in delivering public services but had also brought risks to the forefront of policy debate.

A. Fiscal Operations

Digitalization in revenue administration has progressed steadily over the past decade but at an uneven pace. Considerable progress was made in adopting digital tools that help reduce transaction costs and improve taxpayer satisfaction. For example, as of 2019, taxpayer online registration was available in 97 percent of advanced economies and 80 percent of emerging market economies. However, only half of low-income developing countries provide this service to taxpayers. Similarly, e-filing has become ubiquitous in advanced

economies, whereas low-income developing countries are lagging (Figure 6). The use of e-invoicing and electronic fiscal devices is more prevalent in emerging market economies and low-income developing countries than in advanced economies (Figure 7).[9] This is because of limited overall development of digitalization and financial markets, prompting emerging market economies and low-income developing countries to resort to implementing these tools as second-best (not optimal but feasible) alternatives in digitalization of revenue administration.[10] These technologies increase the availability of transaction-level information and can create trails that improve the administration of VAT and corporate income taxes. Moreover, there is large variation in adoption of analytical tools, such as machine learning, and of application programming interfaces to automatically exchange information across different systems: low-income developing countries and emerging market economies are considerably lagging advanced economies.

Figure 6. Share of Taxes e-Filed by Tax type, 2019 *(Percent)*

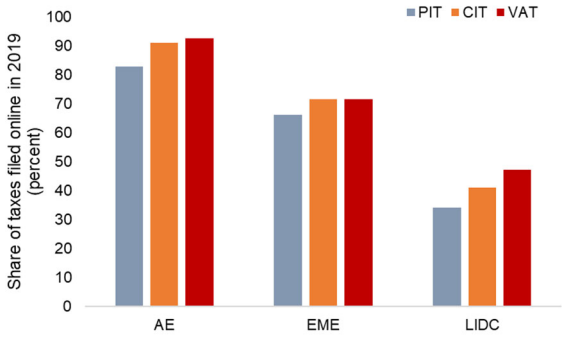
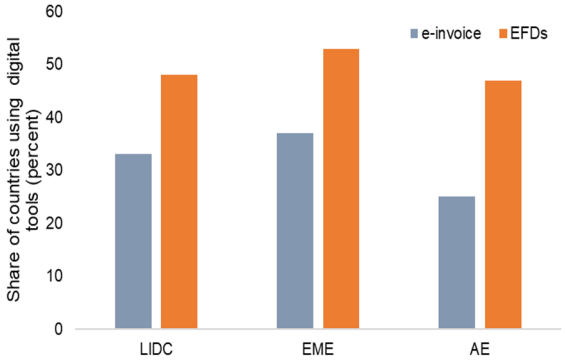


Figure 7. e-Invoicing and EFDs across Countries, 2019 *(Percent)*



Sources: International Survey on Revenue Administration; and IMF staff calculations.
Note: The share of taxes filed online is calculated by dividing the number of taxes filed online by the total number of taxes filed annually. The share of countries using e-invoicing, EFDs, and analytical tools represents the proportion of countries that had implemented these tools in their revenue administration as of 2019. CIT = corporate income tax; EFD = electronic fiscal device; PIT = personal income tax; VAT = value-added tax.

Most countries have achieved some level of digitalization of their core PFM functions. Based on the World Bank's (2022b) GovTech Maturity Index, nearly all countries had achieved some digitalization of budget operations through financial management information systems (FMIS) by 2022 (Figure 8).[11] However, institutional coverage of FMIS varies, and several countries face challenges in making full use of FMIS functionalities.[12] Significant progress has been achieved since 2000 on the launch of treasury single account IT

[9] See Annex I for definitions of e-invoices and electronic fiscal devices.

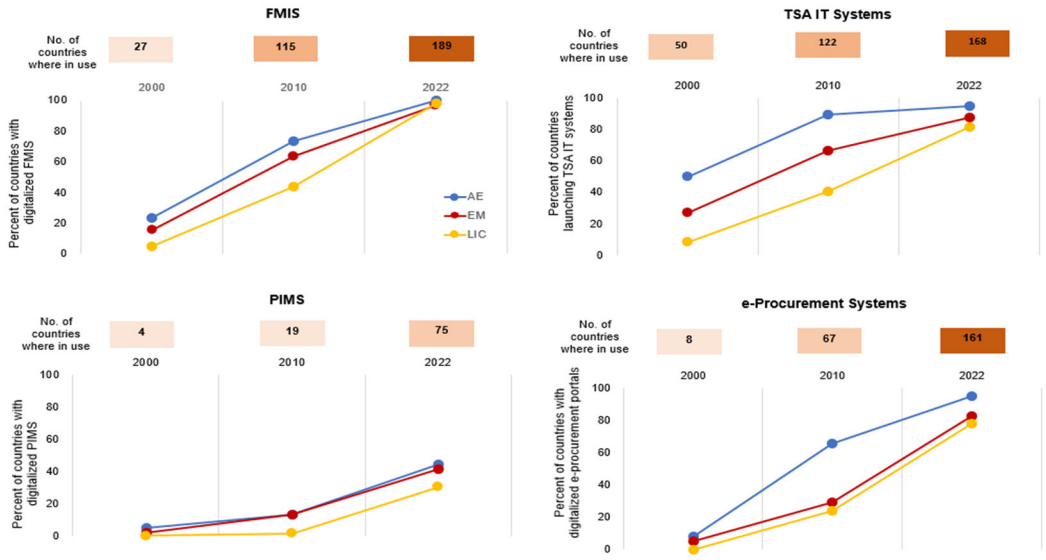
[10] A well-developed financial market enhances the availability of third-party information, which in turn improves the efficiency of tax administration. In contrast, low-income countries with underdeveloped financial systems often face a scarcity of third-party information. As a result, these countries tend to rely on tools such as electronic fiscal devices to help bridge the gap in the availability of third-party information, to increase the effectiveness of tax administration.

[11] The 2022 GovTech Maturity Index covers 198 countries and offers the most comprehensive measure of a country's level of GovTech maturity related to areas including digital government strategy, revenue administration, PFM, and the adoption of disruptive technologies. The data compilation is based on official data and detailed online surveys with relevant government officials at both the central and subnational levels. The compiler verified source data with input from World Bank experts and shared the verified data with country officials for final adjustment before publication (see World Bank 2022a for the methodological details). Despite multiple verification processes, possible measurement errors due to lack of official information should still be noted for cross-country comparisons using the index.

[12] See Annex III for a description of FMIS main functionalities.

systems, but there are gaps in coverage and the degree of adoption. The progress on public investment management systems, which helps systematize registration and monitoring of capital investment projects, has been slower: fewer than half of advanced economies and fewer than a third of low-income developing countries have achieved some digitalization. The launch of e-procurement portals has become common in emerging market economies and low-income developing countries since 2010, but about 20 percent of these countries still do not use e-procurement, and in many developing economies when an e-procurement portal is launched, its capabilities are still limited.

Figure 8. GovTech in Public Expenditure



Sources: World Bank, GovTech Maturity Index; and IMF staff calculations.
Note: FMIS = financial management information system; PIMS = public investment management system; TSA = treasury single account.

GovTech could significantly enhance revenue collection, but its effects depend on the type of tax and on the availability of complementary human and physical resources. A cross-country panel regression analysis suggests that the implementation of e-filing could lead to an increase in tax revenue of up to 3 percentage points of GDP (Figure 9, panel 1).[13] This is an upper-bound estimate as it may reflect the combined impact of several digital tools rather than solely the effects of e-filing and the impact of transition from zero to 100 percent e-filing. Microdata-based quasi-experimental studies support the strong response of taxable income to e-filing (Santoro and others 2022), but others find the impact more ambiguous (Okunogbe and Pouliquen 2022).[14] Furthermore, the analysis also shows that the adoption of e-invoicing and electronic fiscal devices can improve revenue mobilization by 0.7 percent and 0.5 percent of GDP, respectively. Results from quasi-experimental studies show a similarly large impact (Bellon, Khalid, and Lima 2022; Mascagni, Mengistu, and Woldeyes 2021). Moreover, the literature suggests that the impact of digitalization is

[13] See Nose and Mengistu (forthcoming) for details on the regression specification and data used.

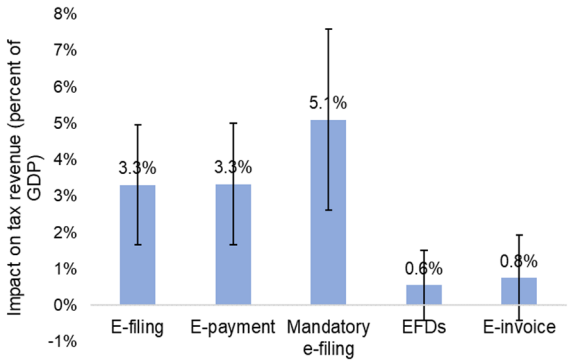
[14] Although taxable income responds strongly, this does not necessarily translate into increased tax revenue in an environment with weak tax administration capacity.

most pronounced in the mobilization of revenue from value-added and corporate income taxes (Mascagni, Mengistu, and Woldeyes 2021). Santoro and others (2022) show that the impact of e-filing on corporate income tax is twice that on personal income tax because of the practice of withholding. Digitalization's impact on revenue administration is enhanced by expanding digital connectivity and ensuring sufficient staffing and expertise among tax officials (Nose and Mengistu, forthcoming).

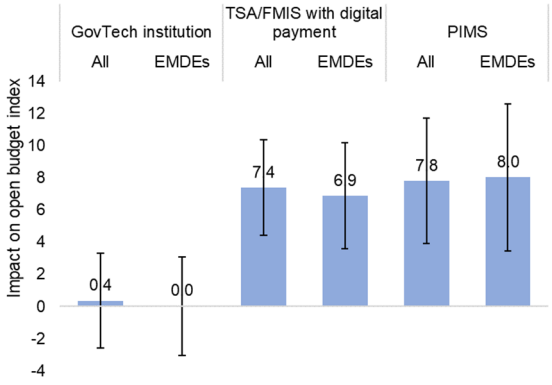
Digitalization in PFM and public expenditure could enhance fiscal transparency and support efforts to combat corruption and mismanagement. A cross-country panel regression analysis indicates that the automation of budget payments using digital technologies is associated with more budget transparency as measured by the Open Budget Index (OBI) (Figure 9, panel 2). This means that many emerging market and developing economies could achieve a higher Open Budget Index rating through digitalization when the adoption of technologies facilitates enhancements in reporting. Introduction of a public management information system could accelerate the improvement in fiscal transparency through systematic registration of capital projects and better management of capital budgets throughout the project cycle. Similar analysis exploring the impact of GovTech indicators on estimates of public spending efficiency suggests that digitalization is generally associated with an improvement in the efficiency of expenditure. The efficiency scores of health and education spending show the most correlation with the GovTech public service quality index.[15]

Figure 9. Impact of Digitalization on Public Finance

1. Impact on Tax Revenue (Percent of GDP)



2. Impact on Open Budget Index



Source: Nose (forthcoming) using IMF, World Bank GovTech Maturity Index, International Survey on Revenue Administration (ISORA), Tax Administration Diagnostic Assessment Tool (TADAT), and Open Budget Survey.
Note: Bars show point estimates of each GovTech variable from fixed effects regressions, controlling for macroeconomic, structural, and institutional determinants of each outcome. Error bars present 95 percent confidence intervals. Digital payment is defined as electronic government transfers with internet or mobile phone. EFD = electronic fiscal device; EMDEs = emerging market and developing economies; FMIS = financial management information system; PIMS = public investment management system; TSA = treasury single account.

Benefits of digital payments and e-procurement are larger for the poor when GovTech enabling fundamentals are in place. The analysis using an event-study method finds that the digitalization of PFM processes, such as payments and procurement, could strengthen the role of public expenditure in achieving

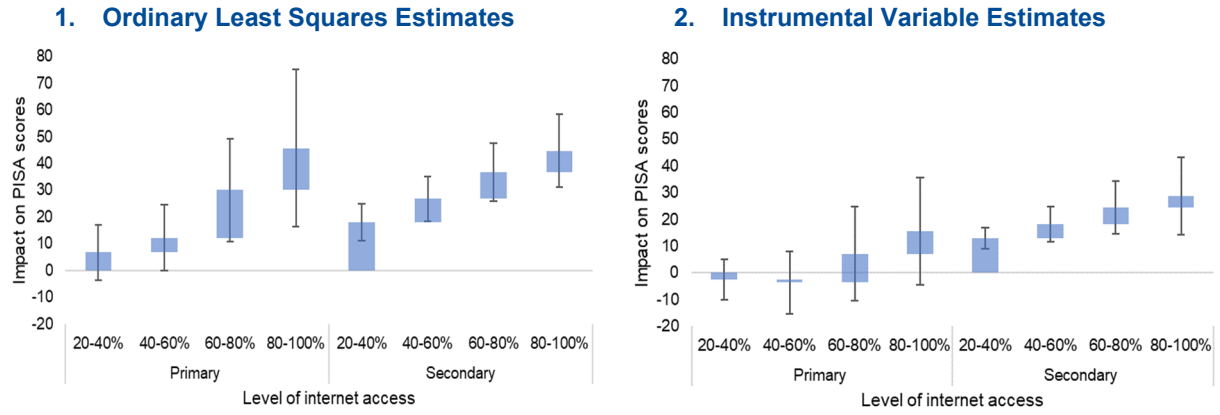
[15] The analysis uses estimates of health and education spending efficiency, which are derived from the Data Envelopment Analysis (Garcia-Escribano, Juarros, and Mogues 2022; IMF 2021). Cross-sectional correlations of health and education efficiency scores with the GovTech public service quality index are 0.52 and 0.72 (both significant at the 1 percent level).

inclusive growth (Zouhar and others 2021). The adoption of digital payments and e-procurement could increase the income shares of the bottom 50th percentile, and for women the most, in countries at the top quartile of GovTech maturity. The empirical results suggest that the improvement in expenditure efficiency hinges on a mature GovTech enabling environment (for example, government officials with strong digital skills, the presence of data-driven platforms), ample digital network coverage, and high state capacity, which are the preconditions for successfully operationalizing digital technologies in budget operations.

B. Education

With digital tools becoming an essential part of education in modern schools, digital adoption can yield significant learning dividends. Empirical results show that digital adoption can significantly improve education outcomes (Kumar, Amaglobeli, and Moszoro 2023). An increase in internet use from 10 to 90 percent is associated with an increase in average primary and secondary education test scores by up to 25 percent (Figure 10).[16] These results are stronger for secondary education and a higher percentile of internet adoption. Introducing educational technologies and internet improves learning outcomes by providing additional schooling resources (see Derksen, Michaud-Leclerc, and Souza 2022 for Malawi; see also, Kho, Lakdawala, and Nakasone, forthcoming, and Rodriguez-Segura 2022) and material to teach students at the right level (Banerjee and others 2007; Muralidharan, Singh, and Ganimian 2019).

Figure 10. Effects of Internet Use on Education Quality



Source: Kumar, Amaglobeli, and Moszoro (2023).
Note: The dependent variable is normalized test scores. To get at causal effects of internet use on education, two econometric strategies are used: difference-in-differences with staggered treatment timing regressions (panel 1) and the same specification with instrumented *Internet Use* (panel 2). For the staggered treatment timing, *Internet Use* is discretized into five bins Q = (0–20%), (20–40%), (40–60%), (60–80%), (80–100%). *Internet Use* is instrumented using a leave-one-out average of internet use at time *t* in the region of country *c*. PISA = Programme for International Student Assessment.

Digital technologies affect education outcomes through different but complementary channels (Michaud-Leclerc and Moszoro 2023). For example, EdTech (equipment and software) and internet at home

[16] Moving from the first bin (0–20 percent) to the fifth bin (80–100 percent) improves the average test score by 29–45 points. With the average test score in the sample of 478 and the minimum of 300, the 45-point increase yields a 25 percent increase in test scores over the effective baseline average of 178 points.

or at school affect students directly or indirectly through parents and educators. Educational software installed on home computers has proved to increase computer skills, most notably for students without prior exposure to computers or internet experience (for example, in China). Yet access to computers at home could reduce test scores (for example, Romania and North Carolina, United States) and academic effort (for example, Peru). Meanwhile, equipment and software at school help reduce the learning gap among students (Muralidharan, Singh, and Ganimian 2019; Rajendran and Muralidharan 2013), help teachers plan classes (for example, Kenya), complement teaching with videos (Ganimian, Vegas, and Hess 2020; for example, Pakistan), and assist principals (see Darling-Hammond and others 2022; Pont, Nusche, and Moorman 2008, for example, United States). The Internet can also serve as a communication medium between parents and schools to monitor grades and attendance and to receive feedback (Goodall 2016; Heath, Maghrabi, and Carr 2015; for example, United States), and for students to increase access to information for university or career options (for example, Uruguay).

To be most effective, digital interventions in education should be carefully designed. The Internet may also serve as a distraction (Malamud and others 2019) and a source of misinformation (Lazer and others 2018), which consequently can impede learning or have negative consequences on students' mental health (Braghieri, Levy, and Makarin 2022). Understanding the potential positive and negative impact of digitalization on young learners is crucial. Parental controls to monitor children's internet usage might be an important feature to restrict internet usage as a source of distractions at home. Training teachers is essential to positive effects of the internet on students' learning (Benalcázar and others 2021); however, the internet is not a good substitute for teachers. An exception is distance learning interventions, which can reduce the rural-urban learning gap and have a positive impact on learning (Bianchi, Lu, and Song 2022). The advantages of distance learning manifested during the COVID-19 lockdowns, when in-person classes were often nonviable (Cone and others 2022). The effects of the internet at schools may appear only in the long run after teachers have incorporated it into the classroom and school curriculum.

C. Health

GovTech can help improve quality of care, increase the coverage of underserved populations, and optimize resource utilization (Wang and Bloch, forthcoming). The system of electronic health records, telemedicine, and digital platforms for patent licensing and the procurement of medicine and for monitoring of infectious diseases are areas of digital innovation in health care.

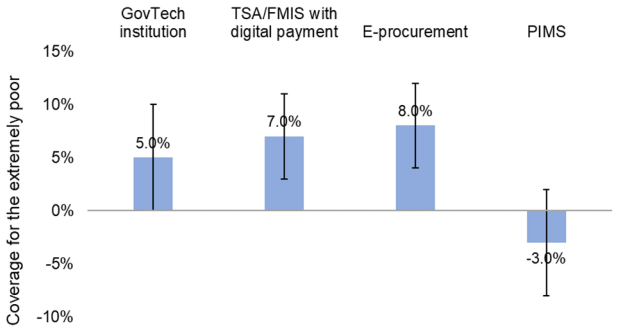
The system of electronic health records is an important component of health care digitalization. Data collected from such records can inform diagnostics, monitor diseases and health security, and provide valuable evidence on which to base policy decisions (including on resource allocation). At a microeconomic level, well-organized health information systems give health care professionals timely access to accurate patient data and medical history. In Estonia, an estimated 15–17 percent of prescriptions are changed when doctors receive warnings of drug interactions through the e-prescription system. In Korea, in 2021, the government launched a mobile-phone-based public personal health record application that integrates medication and vaccination data, links to wearables and interoperates with hospital electronic medical records (Lee 2022). Governments should ensure that the collection and use of health care data are safe and well regulated (Wang and Bloch, forthcoming).

Telemedicine can help address the scarcity and uneven distribution of quality health care services. In Brazil, following the development of the e-SUS health care system integrator, there is a growing number of primary care units using digital records and health care professionals using laptops and tablets (CETIC.BR 2021). In China, given the uneven distribution of high-quality health care services, Ping An—an umbrella health care provider—developed the "Good Doctor" service, which allows patients to connect virtually to doctors for consultation. By 2019, Ping An's Good Doctor had 315 million registered users and boasted an AI doctor that can answer patient questions and provide recommendations to doctors to increase efficiency (Wang and Bloch, forthcoming). In Malawi, the African Drone and Data Academy has been educating students on drones to transport blood between clinics (Holst and others 2020).

Digital platforms can facilitate patent licensing and drug procurement for developing economies. The Medicines Patent Pool uses digitalization tools to build a transparent drug patent database (MedsPaL) and share available licenses online, using the internet to reduce information friction in drug licensing. Digital platforms also make the drug procurement process easier, facilitating pooled procurement across and within countries. The Global Fund's Pooled Procurement Mechanism allows countries to pool drug orders into larger volumes for better discounts, track order status, enter data directly, and enhance the quality of reporting and monitoring. Research finds that pooled procurement institutions lower prices, which is particularly valuable for small countries and in more concentrated drug markets, with reduced delivery delays—but at the cost of longer advance procurement planning (Wang and Zahur 2022).

Digitalization has made it easier to monitor the spread of infectious diseases (Bansal and others 2016). Public health officials can use data from social media, internet searches, and other digital sources to identify outbreaks and track the spread of diseases. This allows for faster response and better-targeted interventions. Countries have developed digital disease surveillance tools such as the Integrated Disease Surveillance Project (IDSP) in India and the Electronic Disease Early Warning System (eDEWS) in Yemen.[17] Similar systems were introduced in Ghana (Integrated Disease Surveillance and Response system), Kenya (Health Information System), and Rwanda (Health Management Information System) (Mamuye and others 2022).

Figure 11. Impact of Digitalization on Social Safety Net Coverage



Source: Nose (forthcoming).
Note: Bars show point estimates of each GovTech variable from fixed effects regressions, controlling for macroeconomic, structural, and institutional determinants of each outcome. Error bars present 95 percent confidence intervals. Digital payment is defined as electronic government transfers with internet or a mobile phone. FMIS = financial management information system; PIMS = public investment management system; TSA = treasury single account.

D. Social Safety Nets

Digitalization can help strengthen social safety nets through better identification, verification of eligibility, and provision of delivery mechanisms. Spending efficiency—that is, more adequate and better coverage—can be improved by

[17] See IDSP: https://idsp.nic.in/ and eDEWS: https://www.emro.who.int/pandemic-epidemic-diseases/news/strengthening-yemens-disease-early-warning-system-during-the-covid-19-pandemic.html.

targeting using socioeconomic data to reduce leakages stemming from identification and verification problems, including "ghost" beneficiaries and fraud, and through the use of digital government transfers (Bird and Hanedar, forthcoming). Digital payments can lead to fiscal savings; a shift from physical cash payments to financial transfers eases the burden on frontline service providers of managing cash. However, gains are not automatic, as outcomes are shaped by institutional and economic conditions as well as the objectives underpinning reforms (Gelb, Mukherjee, and Navis 2020). A cross-country analysis indicates that various GovTech indicators are positively associated with social safety net coverage. For example, the automation of budget payments using digital technologies could help with the expansion of the coverage of social assistance programs for the extremely poor by 7 percent (Figure 11). This result is in line with other positive effects that digitalization of PFM has on efficiency of spending, discussed previously.

During COVID-19 many countries used digitalization to scale up social assistance. Countries that were able to use digital databases and trusted data sharing to identify beneficiaries reached on average 50 percent of their population, while countries that had to rely on collecting new information reached on average only 15 percent of their population (World Bank 2022b). A review of six case studies by IMF staff members shows that in countries with existing social safety nets and financial management information systems, both horizontal and vertical expansion supported new and existing beneficiaries (Table 1).[18] In contrast, countries without an existing flagship social safety net—such as Togo and the Democratic Republic of the Congo—introduced new programs for beneficiaries (Bird and Hanedar, forthcoming). Countries with existing social registries, integrated government databases, and stronger financial management information systems were able to expand their social safety nets faster, cover more people, and broadly support shock-responsive social safety nets. In countries with limited government capacity (for example, Democratic Republic of the Congo and Togo), mobile phones were essential to swift registration campaigns and mobile money transfers. Developing sustainable long-term solutions for mobile government-to-person transfers for social assistance requires iteratively adapting a regulatory framework, building infrastructure, and choosing the right collaboration partners (Davidovic and others 2020).

Table 1. Characteristics of Digital Responses to Expand Social Safety Nets during COVID-19 in Selected Case Studies

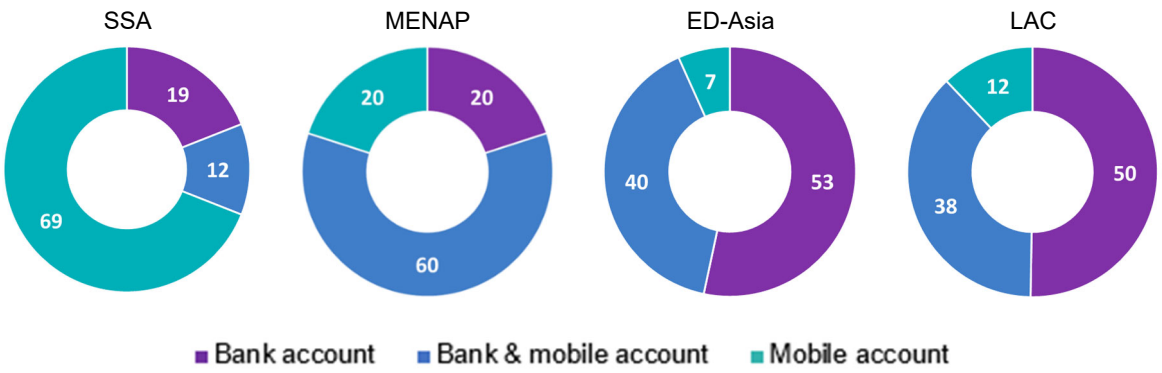
	Social Registry	Digital Registry And Enrollment	Screening Using National ID	Payment Mechanism	Intervention	Type of Intervention	Beneficiaries (Millions)	
							Existing	New
Brazil	Y	Y	Y	New bank accounts	Auxilio Emergencial	H & V	19.5	49.7
Congo, D.R.	N	Y	N	Mobile money	Social transfers in Kinshasa	H	0	1.3
India	N	N	Y	Bank accounts	Direct benefit transfer	H & V	38	17
Pakistan	Y	Y	Y	Cash mainly	Ehsaas cash transfer	H & V	4.5	7.5
Togo	N	Y	Y	Mobile money	Novissi cash transfer	H	0	1
Türkiye	Y	Y	Y	Multiple	Emergency cash transfer	H & V	4	8

Source: IMF staff based on Bird and Hanedar (forthcoming).
Note: "H" refers to horizontal expansion (temporary inclusion of new beneficiaries) and "V" to vertical expansion (temporary increase of the benefit level or duration of the benefits).

[18] Horizontal expansion refers to temporary inclusion of new beneficiaries; vertical expansion refers to temporarily increasing the benefit level or duration of the benefits.

Generally, digital payments used for social assistance relied on bank accounts or a combination of mobile money and bank accounts, except for social safety net countries, which relied on mobile accounts (Figure 12). In most countries, digital payments used to deliver COVID-response social assistance had already been introduced to some extent prior to the pandemic. Several countries, such as Angola, Cameroon, and Liberia, used them for the first time, facilitating a long-term shift to modern social assistance payments.

Figure 12. Social Safety Net Delivery Mechanisms during COVID-19 ***(Percent of countries by region)***



Sources: World Bank (2022b); and IMF staff calculations.
Note: ED-Asia = emerging and developing Asia; LAC = Latin America and the Caribbean; MENAP = Middle East, North Africa, and Pakistan; SSA = sub-Saharan Africa.

IV. Doing It Right

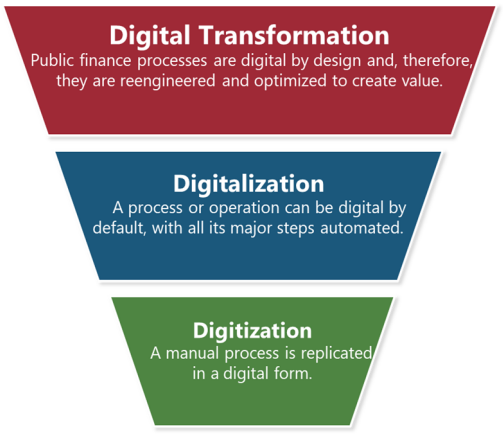
A. Government Strategy

Digitalization can yield large social dividends and transform government only if it is done right. Implementing large digitalization programs is a complex undertaking and requires careful planning, adequate resources, political support, and the adoption of appropriate change management processes. The adoption of digital building blocks, which can boost the innovation of the entire GovTech ecosystem, represents a step-by-step approach for developing digital solutions across different agencies. These digital building blocks can be connected to allow for the exchange of information to support wider digitalization initiatives. This section discusses the main considerations for carrying out large digitalization reforms right.

A national digital strategy is essential for broader adoption of digital technologies in fiscal operations. It serves as a comprehensive plan that outlines a country's digital vision and road map, encompassing goals, policy initiatives, and efficient resource utilization. The Organisation for Economic Co-operation and Development (OECD 2022) has developed a framework comprising seven dimensions to guide national digital strategies, including aspects such as access, use, innovation, jobs, society, trust, and market openness. This framework emphasizes the interconnection of various policy domains and highlights the importance of data governance across all dimensions. The strategy needs to consider the potential impact of Big Tech companies on a country's digital ecosystem, including data privacy and cross-border data flow issues, which may require

appropriate regulations and policies. The success of a national digital strategy depends on four foundational elements to prevent a fragmented approach and avoid duplication of efforts.

Figure 13. Three Stages of Digitalization

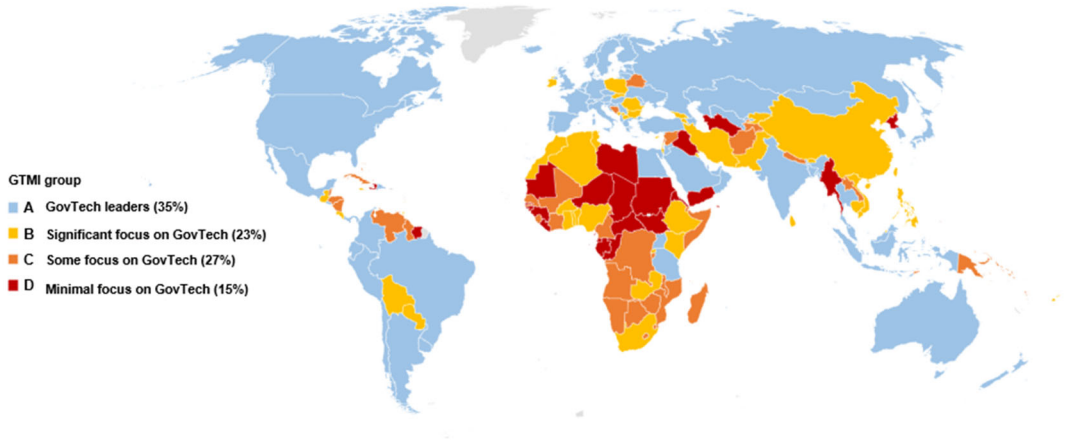


Source: IMF staff

- **Digitalize government services around users' needs.** GovTech initiatives should prioritize the digitalization of government services based on users' needs. Adopting agile methodologies, inspired by start-up practices, enables faster delivery and adaptability to meet the evolving needs of citizens.
- **Promote private sector participation to deliver responsible innovation.** By partnering with the private sector governments can promote responsible innovation—the practice of developing, regulating, and adopting digital technologies considering privacy issues and social, ethical, and environmental impacts.
- **Mitigate risks through legislation to protect privacy, cope with systemic risks, and invest in training of public officials.** Enacting laws and regulations that ensure data protection and safeguard citizens' rights is crucial. Furthermore, a national strategy is necessary to cope with systemic risks, highlighting the need for systematic mitigation across people, technology, and processes. The people layer requires special attention, as 80 percent of all data breaches involve errors by an unsuspecting employee (Verizon 2022). Training government officials is essential to minimize errors and enable them to handle digital risks effectively. International collaboration helps governments stay up to date as risks evolve faster than individual countries' capacity to cope, as in the case of AI-related risks.
- **Focus on hard-to-reach households.** Given the extent of the digital divide, a national digital strategy must explicitly consider how digitalization efforts can promote inclusion to ensure that policy initiatives benefit all individuals (Section II).

Government strategies should consider the stage of transformation of fiscal operations to be achieved through digital solutions. Advancing to the initial level of maturity—*digitization*—requires replicating a manual process in a digital form (Figure 13). This replication in a digital form brings some efficiency gains but falls short of fully leveraging the benefits from digital technologies. At the *digitalization level*, a process can be digital by default, with all its major steps automated (for example, rules-based systems that trigger authorizations and action). At the apex of digitalization—*digital transformation*—public finance processes are digital by design (including through business process reengineering) and aim to produce new outputs or services and enhance citizens' interaction with government. Developing economies have an opportunity to leapfrog from relatively basic infrastructure to the latest digital technologies. Estonia is a remarkable example, starting from a low infrastructure base after independence from the Soviet Union. Since the 2000s, Estonia has made rapid progress on the maturity spectrum and currently operates in a fully digitalized environment (Figure 14).

Figure 14. GovTech Maturity Index

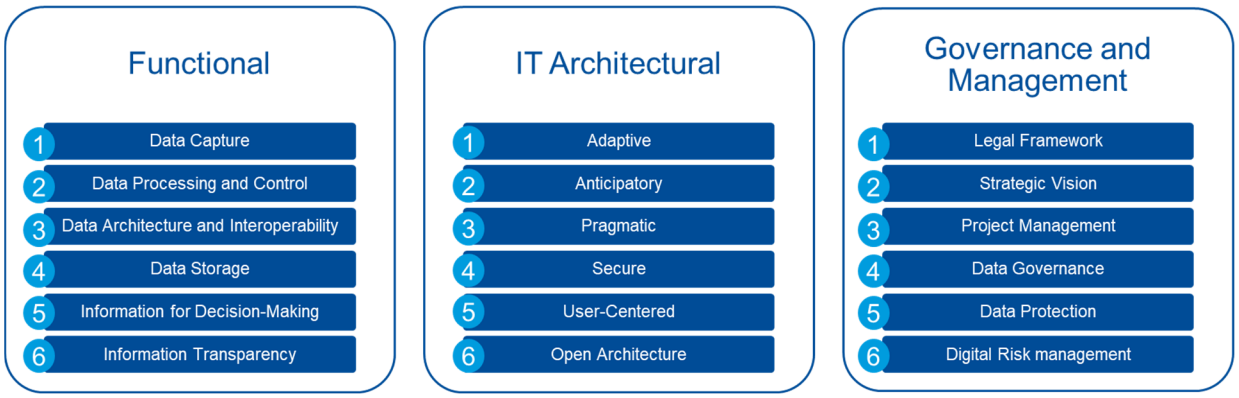


Sources: Dener and others (2021); and World Bank (2022).

B. Transforming Public Finance

Digital solutions for public finance initiatives need to be founded on three key interrelated pillars (Figure 15). First, they must be *functional*, which refers to how digital solutions are used to support, automate, or redesign a business process. Second is the *IT architectural* pillar, denoting the necessary attributes of the underlying technology, including cybersecurity considerations. The third pillar is *governance and management*, which include legal and institutional aspects that should support maximizing the use of the technology. All three pillars are important and need to be considered holistically in digitalization projects to transform fiscal operations through efficient use of public resources. Each pillar can be further disaggregated into more granular attributes reflecting the specific characteristics of the digital solution relevant for fiscal operations (see Annex III for an example of these attributes for public financial management functions). It is important to recognize that these initiatives are not just technology projects, and governments must consider institutional and technological capacities, financial resources, user interfaces, regulatory changes, and change management initiatives.

Figure 15. Pillars of GovTech for Public Finance



Source: IMF staff.

IMF Capacity Development focuses on all three aspects of the implementation of GovTech solutions for public finance. Capacity development aims to strengthen institutional capacity in countries through direct delivery of strategic and operational support, peer learning events, training, and workshops. In addition, the IMF publishes technical and operational notes to provide strategic advice and support capacity development. It collaborates with other providers to develop GovTech solutions. For example, through the organization of hackathons, IMF staff partner with local authorities, the private sector, and academia to help develop quality and functional prototypes of GovTech solutions for national treasuries and revenue administrations. To ensure sustainability of these initiatives, the IMF collaborates with other development partners to support the implementation of prototype solutions and, when feasible, develop them into open-source digital public goods. The IMF continues to support country authorities with the rollout of financial management information systems in treasuries and in ensuring that functional capabilities of new systems are exploited to their full extent. In revenue administrations, IMF staff support efforts to digitalize processes to improve operational efficiency and reduce costs associated with revenue collection by facilitating voluntary compliance and improving taxpayer satisfaction. Moreover, since the implementation of GovTech solutions results in the generation of massive amounts of data, it supports strengthening data management and analytics.

Functional

While models for IT systems for fiscal operations vary widely across countries, they all share basic functionality and design principles. The digital solutions for fiscal operations typically include core and auxiliary IT systems and several IT support systems (see Annex IV), which should be designed following a set of common functional attributes. In addition to maximize the value of digital transformation, the integration of core PFM and revenue administration systems can be helpful, as was the case, for example, in Georgia.[19] Strengthening the feedback loop between PFM and expenditure policy using the wealth of data available in financial management information systems and various other public sector IT systems would facilitate evidence-based fiscal decision-making.[20] Similarly, capturing structured feedback from tax enforcement activities (for example, audit in tax administration, examination in customs) can dramatically improve the effectiveness of revenue administration.

In the world of digital transformation, data is a strategic asset. The ability to make the most of this asset, however, requires an approach to data that is sensitive to national context, levels of institutional maturity, and the availability of staff with the skills required for data analytics. For example, in Mozambique, data collected through the financial management information system allowed for detailed reporting of transactions, providing the essential foundation for data analysis. By contrast, in Brazil, the introduction of a digital accounting platform (SPED) enabled the transformation of business processes both within the tax administration and across large segments of the business community. The underlying data reported through the new platform (comprising high volumes of accounting information—for example, invoices, bookkeeping, payroll records) reduced costs of compliance while dramatically increasing the volume of data captured. In Guatemala, for example, the introduction of electronic tracking devices on cargo trucks resulted in a reduction of the diversion of goods by

[19] Two important reforms have been highly recognized by the private sector as well as implemented jointly by the State Treasury and Revenue Service of Georgia recently: (1) introduction of a unified tax code for all taxes—the amount paid using the unified code will be reflected on the taxpayer's individual tax card against the tax that is due; and (2) automated tax refund—once a taxpayer files a tax return that generates an excess amount on certain tax, the revenue administration system triggers a transaction in the Treasury to refund the amount.

[20] The IMF's *Guidelines for Digital Solutions for PFM* (forthcoming) provide a general framework for the design, assessment, and improvement of PFM IT systems to ensure that PFM functions are carried out efficiently and effectively while ensuring transparency and accountability, enabling innovation, and mitigating digital risks (see Annex II). The IMF is also developing granular guidance on how PFM processes could be digitalized.

99 percent. Open data is critical to promoting innovation and value creation, which often comes from external use of government data.

Artificial intelligence (AI) initiatives could support data-driven decision-making. AI can enhance the generation of timely and reliable fiscal information and improve control mechanisms. AI initiatives—such as machine learning, natural language processing, and robotic process automation applications—have great potential to promote the transformation of fiscal operations. For example, adopting a machine learning application to forecast daily government Treasury shortfalls/surplus could support the definition of the most efficient cash plan. Machine learning applications could also help identify high-risk Treasury payments to prevent irregular transactions. In a similar way, a natural language processing "contract management" type application could speed timely identification of fiscal risks from clauses in the multiple contracts signed by state-owned enterprises that include financial obligations with third parties that must be financially covered by the Treasury. In the case of robotic process automation, an application could automatically generate payment orders based on an invoice submitted electronically by a vendor and could automate its validation and required budgetary control. Robotic process automation improves efficiency, reduces the risk of corruption, and generates timely, accurate, and reliable fiscal information. However, the risks associated with the adoption of AI initiatives, such as the bias introduced by the data training set and data privacy issues, should be carefully considered.

Architectural

The IT architecture for digital solutions should be flexible and scalable, forward-looking, intuitive, and secure and should maximize reusability of software components and data standards. Adopting a modular approach to implementing digital public finance initiatives is an efficient strategy. For example, replacing the current financial management information system with an entirely new system may not be an optimal strategy. By utilizing the latest technology, a better approach may be to update or replace one or more core modules of the system: the so-called modular approach (Uña, Allen, and Botton 2019). The suitability of a modular approach will depend, among other things, on an analysis of the costs and benefits of alternative solutions and the level of coupling and cohesion in the current IT system.[21] Since the mid-2000s, information systems have been gradually developed on web-based platforms under service-oriented design, which has increased system capacity for interoperability and the ease of upgrades or maintenance under a modular approach.

A government-wide strategy for efficiently investing resources in technology should be a key priority. Traditional approaches involve creating digital infrastructure and services tailored to specific needs of government agencies. This can, however, lead to duplicated efforts and inefficiencies. Reusability of technologies should be encouraged by creating digital building blocks—including digital solutions, applications, platforms, and components—that can be easily reused across the government or even by other governments. This approach promotes efficiency and cost savings by avoiding duplication of efforts and resources**.** Such digital building blocks can serve as components to build larger systems or applications, avoiding the process of developing digital solutions from scratch several times (Alonso and others 2023). Some of the most prominent examples of a world-class digital public infrastructure based on digital building blocks are the India Stack and the GovTech Stack of Singapore. For example, the India Stack—a collective name for digital public infrastructure with three layers: unique identity (Aadhaar), payment system (for example, United Payments Interface), and data exchange (DigiLocker and Account Aggregator)—enables online, paperless, cashless, and

[21] In software engineering, the term "coupling" refers to the degree of interdependence between software modules—a measure of how closely they are connected.

privacy-respecting digital access to public and private services. It fosters innovation and competition, improves financial inclusion, and boosts government revenue collection (Alonso and others 2023).

Governance and Management

Digital transformation of fiscal operations needs to be accompanied by required legal and institutional reforms to fully benefit from the technology. Many digitalization projects have been delayed or canceled for lack of legal clarity and complex procurement practices. To create an enabling environment, legal and regulatory frameworks should be reviewed and revised as necessary to promote innovation, transparency, and interoperability, as well as to define norms and rules for data storage and preservation to support e-archiving. Studies also recommend institutionalizing the digitalized processes and solutions in laws or regulations as appropriate and putting in place institutional mechanisms for coordination, as digitalization requires collaboration at many levels (Dener, Watkins, and Dorotinsky 2011; OECD 2019; Pimenta and Seco 2021). In addition, traditional procurement laws and regulations should be reviewed, updated, and streamlined to better address the unique challenges of digital technology.

A properly designed and executed project underpinned by a change management strategy is vital to successful implementation and sustainability of digital transformation of fiscal operations. Project management should include a well-designed plan linked to the broader government IT strategy and a capable team to enable agility, iteration, experimentation, and continuous improvement. Project procurement should be carefully considered to avoid delays, cancellations, and vendor lock-in. The project team should include officials from both the business area and IT department. Studies also suggest that digitalization extends beyond automating processes to a shift in culture and mindset, requiring robust change management and communication (World Bank 1998; Fritz, Verhoeven, and Avenia 2017; Uña, Allen, and Botton 2019; Pimenta and Seco 2021). Change management requires leadership support and needs to consider both internal operations and personnel and external stakeholders. It should take into account required new skills and job profiles (for example, IT professionals and data specialists) to support digitalization and take into consideration existing jobs and skills that will become obsolete. Developing and implementing a training and communication plan should be a key component of change management. For example, Maldives ensured early training of its officials and organized several public awareness programs during financial management information system implementation.

The protection of data acquired or used by governments is crucial in maintaining the privacy and security of citizens. Beyond the obvious impact on citizens' trust, data breaches can lead to severe financial consequences. In recent years, the cost impact of data breaches across the world has been staggering. IBM estimates that the average cost of a data breach around the world in 2022 was $4.35 million per incident, and 83 percent of organizations have experienced more than one data breach.[22] The cost of a data breach in the government sector can be even more devastating, as it can lead to national security threats and jeopardize the trust between the government and its citizens.[23] Therefore, it is imperative to implement robust security measures to protect sensitive information held by governments (see Annex V).

Comprehensive data protection legislation is still lacking in many countries, placing privacy and other digital rights of users at risk. Privacy is a fundamental right of citizens, and governments have a responsibility to implement a robust regime for data protection. Data protection legislation needs to strike an

[22] https://www.ibm.com/downloads/cas/3R8N1DZJ.

[23] The World Economic Forum's *Global Risks Report 2019* reported that "The largest (data breach) was in India, where the government ID database, Aadhaar, reportedly suffered multiple breaches that potentially compromised the records of all 1.1 billion registered citizens."

appropriate balance between protecting citizens' rights and fostering innovation. A robust data protection framework is essential to protect citizens' privacy, prevent companies and governments from indiscriminately collecting data, hold companies and governments accountable for data breaches, and incentivize appropriate data handling and adequate investment in cybersecurity.

V. Conclusions

Digitalization is transforming public finances and, if done well, can yield large social dividends. Digital adoption facilitates better access to basic public services and can help improve education and health outcomes and strengthen the effectiveness and efficiency of social safety nets. Governments have an important role to play in facilitating digital adoption in the economy and in public finance. Many governments have adopted policies, both on the supply and demand sides, to facilitate digital adoption. Implementation of digital solutions in fiscal operations can also yield significant dividends by increasing revenue collection, strengthening transparency of public finances, and improving spending efficiency. Successful implementation of digitalization requires embedding government programs in national digital strategies. The IMF supports governments in their efforts to adopt GovTech solutions and transform fiscal operations through capacity development and training.

Digitalization also generates the need and opportunity to redesign fiscal policies. To the extent that digitalization presents new opportunities for tax evasion (for example, through the use of cryptocurrencies), policies should be adapted to minimize risks for tax collection. Yet the availability of more extensive and reliable information also enables governments to reform their tax systems to make them more equitable and efficient. For example, the increased availability of third-party information on (offshore) assets enables governments to enhance the taxation of capital income. And if governments can link information on transactions (for example, through blockchain access) to information about personal income, they can design a progressive value-added tax. On the spending side, the same or better income redistribution can be achieved by tightening eligibility requirements for recipients of social assistance.

Digitalization is not a substitute for good governance. Implementing digital solutions can yield benefits only when they are accompanied by efforts to strengthen institutions. Digitalization may require changes in regulations and established processes and strong safeguards for data security and privacy to protect sensitive information. Implementing complex digital solutions when institutional capacity is weak and lacks adequate safeguards could even be counterproductive and could lead to worse outcomes by facilitating corruption. Moreover, complementary digital literacy training is essential to ensure smooth implementation of new solutions and effective use of all capabilities of new technology. Finally, adequate infrastructure, such as hardware platforms and internet connectivity, is necessary to effectively implement digital solutions.

Annex I. Glossary of Key Terms

Term	Definition
5G	The fifth generation of cellular technology, succeeding 4g, 3g, and 2g (GSM—Global System for Mobile Communications) systems. It is designed to increase speed, reduce latency, and improve flexibility of wireless services. It is estimated that 5g will cover one-third of the world's population by 2025, mostly in advanced economies.
Application programming interface (API)	A set of defined rules that specify how application components should interact or integrate with other services and applications within or outside an organization. APIs can be used to create new applications, extend the functionality of existing applications, or integrate different systems. This facilitates data exchange between systems.
Artificial intelligence (AI)	The rapidly evolving field of computer science that focuses on the development of intelligent machines that can reason, learn, and act in ways that simulate human intelligence, such as recognizing speech, understanding natural language, making decisions, and recognizing patterns in data. It can help businesses automate processes, reduce costs, and improve efficiency and decision-making.
Automation	Integration of processes and tasks so that they run autonomously and automatically. Automation is the part of digitalization that automates processes with minimum human involvement. Automation can directly impact the labor market and potentially increase redundancy of employees in the public sector; digitalization does not necessarily have this effect.
Big Data	Large and complex data sets that can include structured, semistructured, and unstructured data from various sources, such as social media, sensors, and survey responses. It allows organizations to uncover hidden patterns, previously unknown correlations, and customer preferences to gain insight into customer behavior, optimize business operations, improve decision-making, and develop new products and services.
Blockchain	An advanced database mechanism that allows transparent information sharing within a network. A blockchain database stores data in blocks that are linked together in a chain, in a manner that prevents tampering. As a result, some projects use blockchain technology to create an unalterable or immutable ledger for tracking orders, payments, accounts, and other transactions. Blockchain, in itself, is only a storage mechanism with a distributed governance.
Cybersecurity	A set of practices, technologies, and processes designed to protect digital assets such as computer systems, networks, and data from unauthorized access, modification, theft, damage, denial of service, or other malicious activities. Its primary objective is to guarantee the confidentiality, integrity, and availability of data and information systems.
Data architecture	The rules, policies, and process of managing data from collection through to transformation, distribution, and consumption. It sets the blueprint for data and the way it flows through data storage systems. It is foundational to data processing operations and artificial intelligence (AI) applications.
Data governance	A set of processes that ensures that data assets are formally managed throughout an organization. A data governance model establishes authority and management and decision-making parameters related to the data produced or managed by the organization.

Data loss	Unintentional or accidental loss of data that is in digital or physical form. This can happen due to a variety of reasons, such as data theft or destruction, failure or malfunction of hardware or software storing the data, human error, or malicious attack.
Digital building blocks	Applications, platforms, and systems that can be reusable across different government areas and can serve as a component to build larger systems or a technological stack, avoiding starting the process of developing digital solutions from scratch several times. These types of applications and platforms are generally developed on open-source software, and they accomplish basic but widely useful functions, such as digital identification. Digital building blocks have four main characteristics as a technological solution: autonomy, generic capabilities, interoperability, and evolvability.
Digital divide	A gap between people who have access to digital technologies or services, such as the internet, and those who do not. Those without access may lack essential computer skills or access to information that could be beneficial for them to participate in digital economic activities such as education, health care, agriculture, etc.
Digital identification (ID)	An electronic representation of personally identifying information that may be used to authenticate people's identity and grant them access to various digital services.
Digital learning	Any instructional practice that effectively uses technology to strengthen a student's learning experience and encompasses a wide spectrum of tools and practices.
Digital payments/e-transactions/e-payments	A broad term including any payment executed electronically. Includes payments that are initiated by mobile phone or computer.
Digital platform	Typically, a central hub for various services, providing citizens with a single access point to multiple services, such as applying for licenses, paying taxes, or accessing health care services. In GovTech, digital platforms enable governments to deliver services more efficiently, reduce administrative costs, improve citizen engagement, and promote transparency and accountability.
Digital public infrastructure (DPI)	Solutions that enable the effective provision of essential society-wide functions and services in the public and private sectors, including digital forms of identification, payments, and data exchange.
Digital resilience	Planning for digital risks or disruptions and building capabilities to detect and respond, recover, and thrive even after the disruption.
Digital tools	Programs, websites, applications, and other internet and computerized resources that facilitate, enhance, and execute digital processes and overall digitalization efforts.
Digitalization	The ongoing integration of digital technologies and digitized data across the economy and society.
e-Filing	The process of electronically submitting tax returns and other related documents to the government. E-filing is more convenient and efficient and can reduce time of administrative or information processes.
e-Government	The use of information and communication technologies (ICT) to transform government operations by making government services more accessible, effective, and accountable.
e-Invoicing	The exchange between a supplier and a buyer of an invoice issued, sent, and received in a structured data format that allows for its automatic and electronic processing. Because the process is

machine-readable, it can seamlessly integrate into the purchaser's accounts without manual data entry.

Electronic fiscal device (EFD) A type of technological device revenue administrations can use to help monitor business transactions. Advanced EFDs are capable of transmitting fiscal data directly to the servers of tax administration organizations.

e-Prescription A prescription health care providers can prescribe to patients digitally and transmit to pharmacies using special software programs and internet connectivity. E-prescription is a more convenient and cheaper form of prescription for doctors, pharmacies, and patients.

e-Procurement The use of electronic and communication technologies in procurement processes to increase efficiency, improve cycle times, reduce costs, and facilitate greater control and visibility in the procurement process.

Fintech Software, mobile applications, and other technologies created to improve and automate traditional forms of finance for businesses and consumers alike. Fintech can include everything from straightforward mobile payment apps to complex blockchain networks housing encrypted transactions.

GovTech The use of technology to modernize and transform government operations, decision-making processes, and service delivery to improve government services, transparency, efficiency, agility with fit-to-purpose technology, and citizen engagement. This includes developing digital tools and platforms, using data analytics and innovative technologies such as cloud computing and artificial intelligence, and promoting transparency and accountability and public and private sector collaboration. GovTech is increasingly important as citizens expect more user-friendly and trusted services and governments seek to address complex societal challenges.

Information systems security The protection of information systems against unauthorized access to or modification of information, whether in storage, processing, or transit and against the denial of service to authorized users, including measures necessary to detect, document, and counter such threats.

Integrated government databases Digital government databases that contain unified data on citizens collected from different sources. Integrated government databases are important for governments pursuing digital transformation strategies to improve operations and organization of services such as e-government services.

Interoperability The ability of different functional units, for example, systems, databases, devices, or applications to communicate, execute programs, or exchange data seamlessly and effectively in a manner that does not require the user to have extensive knowledge of those functional units.

Machine learning The part of artificial intelligence (AI) studying how computer agents can improve their perception, knowledge, thinking, or actions based on experience or data. It involves the development of algorithms and models that can learn patterns and insights from data and make predictions or decisions based on that learning. Machine learning can be used in various applications, such as image recognition, speech recognition, natural language processing, and predictive analytics.

Mobile money Financial transactions and services that can be carried out using a mobile device such as a mobile phone or tablet. These services may or may not be linked directly to a bank account.

Mobile phone penetration A way of measuring the number of active mobile phone users in a particular country. It is usually expressed as the ratio of SIM cards to the total population and does not consider double counting when a person has more than one SIM card.

National digital strategy (NDS)	The policy foundation toward building an innovative, open, agile, and inclusive digital government. An NDS (1) encompass a "whole-of-government" digitalization approach, which therefore encourages ministries of finance to further digitalize their public financial management and revenue administration operations; (2) fosters a coherent approach to digitalize government services and strengthen digital public infrastructure, with citizens and businesses at the core of such transformations; and (3) coordinates cross-cutting digital policies (for example, cloud strategies, data privacy, cybersecurity, and so forth).
Open-access code	Universal and free access to code that is used to create digital systems/platforms/tools and unrestricted use of the code at no cost and free of most copyright and licensing restrictions.
RegTech	The use of technology to enhance risk management and regulatory compliance in financial institutions.
SupTech	The use of innovative technology by supervisory agencies to support supervision. It helps supervisory agencies digitize reporting and regulatory processes, resulting in more efficient and proactive monitoring of risk and compliance at financial institutions.
Telemedicine	The use of telecommunications or digital technologies to support the delivery of medical, diagnostic, and treatment-related services, usually by doctors who are not located in the same place as the patient.
Universal broadband connectivity	A theoretical concept that aims for all people, regardless of geographic location, socioeconomic status, race, gender, or any other differentiating demographic characteristic, to have access to affordable services and devices so that they can connect to reliable and safe internet; participate in the digital economy; access education, health care services, and so forth; and connect with others.

Annex II. Selected Government Support Programs to Foster Digital Adoption

The following table summarizes selected government programs aimed at increasing digital adoption. Program objectives are categorized as coverage, affordability, quality, and usability. “Coverage” means reaching remote and rural areas; “affordability” means lowering the price for vulnerable groups and reducing barriers to entry for internet providers; “quality” means increasing the download and upload speed of broadband internet; and "usability” means training in digital literacy skills for use of internet services. The size of the program is reported in millions of US dollars and as percentage of GDP.

Country	Program	Year	Description	Purpose	Size	Comments
Provider-based programs						
Colombia	Plan Vive Digital	2010	Expands internet to 500 municipalities by funding building of fiber-optic infrastructure to provide low-cost internet service through public-private partnerships	Affordability Coverage	$200 million GDP 0.07%	Fiber optics built by multiple private contractors
Ghana	Ghana Rural Telephony and Digital Inclusion	2020	Funds expansion of mobile network to reach 6,000 villages in rural regions to provide basic voice and data connectivity	Coverage	$170 million GDP 0.24%	Government took loans from China EXIM Bank; Huawei is the partner to expand mobile coverage
India	Bharat Net	2018	Aims to provide a high-speed 100 Mbps internet connection in 250,000 village councils (“gram panchayats”) at affordable prices by building fiber-optic connections and Wi-Fi hotspots	Coverage Affordability Quality	$5,100 million GDP 0.19%	Implemented in two phases; second phase started in 2018 and is set to be completed in 2025. Last-mile initiative aims to build a Wi-Fi hotspot in every village council
Kenya	Digital Infrastructure	2018	Part of the National Broadband Strategy (NBS); funds development of digital infrastructure over five years to provide high-speed internet across the country through public-private partnerships	Coverage Affordability Quality	$597 million GDP 0.65%	Total budget for NBS is $1,113 million
New Zealand	Rural Broadband Initiative	2018	Funds building and upgrading of broadband infrastructure to provide improved broadband speed in rural areas through partnerships with private providers	Coverage Affordability Quality	$376 million GDP 0.18%	Implemented in two phases; the second phase is in progress: 80,000 households with improved broadband
Poland	Internet for Mazovia	2012	Funds construction of fiber-optic lines to provide high-speed internet in the Mazovia voivodeship and lease the infrastructure to wholesale private providers to operate the services	Coverage Affordability Quality	$130 million GDP 0.026%	Implemented by multiple private contractors
Spain	Universalization of Digital Infrastructures for Cohesion (UNICO) Broadband	2020	Aims to fund digital infrastructure to expand ultrafast broadband network to 100% of the population, with internet speeds of 300 Mbps to 1 Gbps, focusing mainly on remote areas and public entities	Coverage Affordability Quality	$496 million GDP 0.04%	To be completed by 2026; part of the Digital Spain 2026 Agenda with total funding of $22 billion

Country	Program	Year	Description	Purpose	Size	Comments
Consumer-based programs						
Cyprus	Cypriot Scheme	2022	Provides vouchers to households for monthly subscriptions to high-speed internet for 12 months, with internet speed of at least 200 Mbps; covers setup fee for the service	Affordability Quality	$14 million GDP 0.05%	Until June 2025; 82,000 households projected to benefit; $11 a month and one-time cost
France	Digital Cohesion	2019	Covers cost for individuals and businesses to buy equipment and installation of internet services on their premises through private internet providers	Affordability Quality	N/A*	$329 to $657 per individual for high-speed internet
Greece	Superfast Broadband Project	2022	Provides vouchers for monthly subscriptions to high-speed internet services with a download speed of at least 100 Mbps for up to two years and one-time connection cost	Affordability Quality	$55 million GDP 0.02%	$15 for monthly subscription and $53 for a one-time connection cost; speed of at least 100 Mbps, readily upgradable to 1 Gbps
Spain	Unico Social Bonus	2021	Provides vouchers to vulnerable households to access broadband service of at least 30 Mbps through internet providers.	Affordability Quality	$22 million GDP 0.04%	Maximum $264/year for high-speed internet per household; allocated funds are for 2022–23
United Kingdom	Gigabyte Broadband Voucher Scheme	2022	Subsidizes the cost of installing a gigabit-capable connection at the customer's doorstep by service provider through a voucher	Coverage Affordability Quality	$263 million GDP 0.008%	Speed of 1,000 Mbps; $654.18 to $1,962.54 per resident and up to $4581.03 for small business; part of Project Gigabit, with total funding of $6.22 billion
United States	Affordable Connectivity Program	2021	Provides households discount vouchers for one monthly subscription to internet service and for one internet device per household through a service provider	Coverage Affordability	$14,200 million GDP 0.06%	$30/month per household for internet service and $75/month per household on qualifying tribal lands; $100 to purchase equipment from participating providers to individuals below 200% of the federal poverty level. Part of the Infrastructure Investment and Jobs Act, with total of $65 billion for expanding broadband
General programs						
Bangladesh	Union Digital Center (UDC)	2010	Set up digital centers in each village council office to provide rural communities access to vital services, including e-governance services, information and communications technology training, and access to free or low-cost internet	Usability	$40 million GDP 0.03%	4,554 UDCs have been established; UDC is part of the Aspire to Innovate Program
Canada	Digital Literacy Exchange Program	2018	Equips 400,000 individuals with the skills necessary to use computers, mobile devices, and the internet safely, through nonprofits that work to improve digital literacy	Usability	$14 million GDP 0.001%	$37,000 to $1.5 million per organization to run the programs; focuses on minorities
Costa Rica	National Strategy CRDigit@l	2016	Promotes affordable access to internet by subsidizing equipment and internet services to vulnerable households, building broadband infrastructure to reach remote areas, providing devices to education centers, and providing free access to internet in public spaces	Coverage Affordability	$300 million GDP 0.51%	Reached 12,000 homes in six months under the Connected Homes project; 9,800 devices provided to educational centers; 240 public access points with free internet

Country	Program	Year	Description	Purpose	Size	Comments
France	The Digital Society Program	2020	Aims to train 4,000 digital advisors to teach citizens how to use digital tools tailored to local needs, including but not limited to job training, internet search, and accessing e-government services	Usability	$275 million GDP 0.01%	Digital advisors are in 2,897 locations in all territories; advisors can help with day-to-day activities and through formal training workshops
India	Pradhan Mantri Gramin Digital Saksharta Abhiyan (PMGDISHA)	2017	Provides digital training to one member of each household in rural India to operate digital service devices, access information, and use e-governance services such as digital payment systems from government training centers	Usability	$286 million GDP 0.01%	One member of each rural household gets 20 hours of training: age span 14–60 years
Sri Lanka	Nenasala	2004	Builds and operates low-cost telecenters in rural areas that offer information and communications technology literacy training and provide access to communication and services	Usability	$7.4 million GDP 0.03%	1,005 Nenasalas built as of 2015 in villages with 2,000–5,000 people; the project was awarded US$1 million by the Bill and Melinda Gates Foundation; has improved digital literacy in villages
United States	Broadband Equity, Access, and Deployment (BEAD) Program	2021	Expands high-speed Internet access by funding planning, infrastructure deployment, and adoption programs in all states and territories in unserved and underserved areas.	Coverage Affordability Quality	$42,450 million GDP 0.18%	Initial allocation of $100 million per state and additional depending on need; states must submit five-year action plans. Up to 100 Mbps download speed and 20 Mbps upload speed; part of the Infrastructure Investment and Jobs Act, with total of $65 billion for expanding broadband

Sources: Official government websites; and IMF staff review.
Note: Gbps = gigabits per second; Mbps = megabits per second.
* No public data available on the size of the program.

Annex III. Detailed Attributes for Public Financial Management (PFM) Functions under Functional, IT Architectural, and Governance Pillars

Pillar I. Core Functional Attributes	Pillar II. Core IT Architectural Attributes[24]	Pillar III. Core Governance and Management Attributes[25]
1. Process Transformation. PFM digital solutions should streamline processes, eliminating unnecessary steps and reducing the need for manual intervention. They should automatically apply PFM business rules for control and compliance based on the legal framework, enhancing efficiency, effectiveness, and traceability, as well as aiding the detection of potential deviations from targets and financial mismanagement.	1. ***Adaptive:*** The IT strategy should account for the ever-changing nature of technology, business needs, trends, and emerging risks.	1. ***Legal framework:*** The legal and regulatory frameworks should support the modernization of PFM functions with digital tools. Where appropriate, laws and regulations should be clarified and updated to enable innovation, promote transparency, and prioritize interoperability.
2. Data Capture. PFM IT systems should (i) support gathering and consolidating timely, comprehensive, and reliable data that are generated along the PFM cycle and/or required from specified outside sources to support PFM functions; and (ii) enable automating data gathering and data consolidation across the general government.	2. ***Anticipatory:*** Implementation and modernization of PFM systems should be designed in a forward-looking manner, prioritizing adoption of new technologies before converting legacy systems. This should be accompanied by a cost-effectiveness and sustainability analysis	2. ***Strategic vision:*** The organizational culture should recognize the value of innovation and foster an enabling environment for comprehensive digitalization reforms.
3. ***Data architecture and interoperability:*** The data architecture embedded in the PFM IT systems should be designed to allow agile and secure exchange of data internally and externally. The data architecture should avoid the development and growth of disconnected databases or siloed systems that have difficulty interoperating with other PFM functions or systems. Interoperability should be maintained through a clear and effective data governance program—including shared taxonomy codes, catalogues, and classifications.	3. ***Pragmatic:*** The collection of data should be comprehensive and granular at one entry point, avoiding duplication that could result in redundancies or inconsistencies, with a solid data architecture that promotes data accessibility, usability, reliability, and security.	3. ***Project management:*** There should be a well-designed plan and a well-functioning team that can address any practical and operational issues during the design, procurement, and implementation processes along the PFM IT system project cycle.
4. ***Data storage:*** PFM IT systems should allow storing data for historical data analysis, allowing public access to information and ensuring data integrity.	4. ***Secure:*** PFM IT systems should be designed to meet security and privacy requirements. Embedded security and data privacy controls should guarantee	4. ***Data governance:*** Policies, procedures, and mechanisms should ensure the proper management and quality of data throughout its life cycle,

[24] While some of the architectural attributes comprise similar concepts as that of the core functional attributes, they are presented here from a technological solution point of view.

[25] The core governance attributes described below are closely related and should be considered in a holistic manner.

	that solutions and processed, in-transit, or stored data are adequately protected, reliable, and can be trusted. Ultimately, systems, processes, and practices should be resilient to adapt to the evolving cyber threat landscape.	which is crucial for maintaining transparency, accountability, and informed decision-making in public financial management.
5. *Information for decision-making:* PFM IT systems should provide information that is useful for decision-making under the different roles of the organization, including technical day-to-day operations, managerial decision-making, and oversight roles such as auditing.	**5. *User-centered:*** Digital solutions should be intuitive and adapted to the needs of different user roles. Access models and modes, including multichannel use, should provide flexibility for data analysis, ensure traceability and auditing, generate automated reporting, and provide advanced data analytics and raw data export.	**5. *Data protection:*** Data collected should be handled responsibly, with consideration for its ethical use and respect for privacy rights.
6. *Information transparency:* PFM IT systems should support user-centered transparency of the PFM processes, decisions, and output by enabling the publication of clear, reliable, frequent, timely, relevant, comprehensive, and accessible open data.	**6. *Open Architecture:*** The digital solutions architecture should maximize the reusability of components, as well as of data, between public institutions and other relevant stakeholders.	**6. *Risk management:*** Threats to digital solutions and related data, which can range from systems outages to data breaches and other cybersecurity risks, should be recognized, controlled for, and mitigated up front. While cybersecurity is addressed in the IT architectural principles, this principle covers its management component.

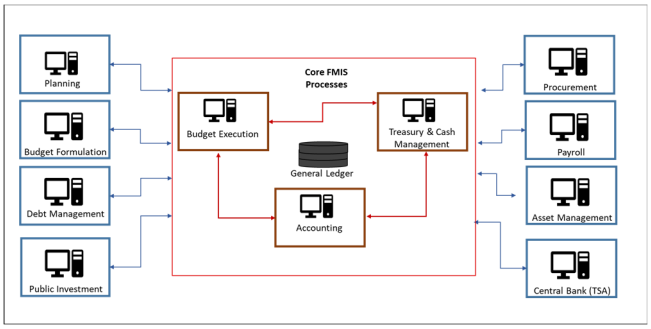
Annex IV. Categories of IT Systems for Public Financial Management (PFM) and Revenue Administration (RA)

Core systems: These systems help automate core fiscal operational tasks and related business processes. They include, for example, financial management information systems (FMIS) on the PFM side and integrated tax administration systems (ITAS) and core customs processing systems on the RA side.

Auxiliary systems: These systems help process auxiliary tasks, whose output generally feeds into core systems. Such systems include e-invoicing, e-filing, e-payment, e-procurement, payroll, single window, and other user-facing systems (for example, historical transactional information).
Supporting systems: These include human resource information management systems (HRIMS), document management, case management, quality assurance, enterprise risk, information security systems, intranet, enterprise reporting, and data analytics.

ITAS Model

FMIS Model



Sources: IMF staff for ITAS Model; and Uña, Allen, and Botton (2019) for FMIS Model.
Note: TSA = treasury single account.

Annex V. Managing Digital Risks

Proper design and implementation of reliable and resilient digital services are at the core of effective and efficient public finance transformation. Heavy reliance on digital services can introduce digital risks such as a single point of failure, should at least one component of the digitalization be disrupted (that is, the technology, processes, or people). Such risks are not limited to cyber-attacks but also include digital fraud, human mistakes, and outages, as well as the risk of widening the digital divide. Building digital resilience is thus a necessity for digitizing public financial management operations. It involves planning and preparing for resilience to mitigate digital risks, as well as adapting during and after the disruptions by responding, recovering, and thriving going forward.

Planning and preparing for digital resilience

The planning and preparation phase involves identifying digital initiatives at risk. This can include digital services that can contribute to digital exclusion or the digital divide or become prone to disruptions, such as by cyber-attacks, thus reinforcing a need to be digitally resilient. For example,

(1) **Privacy risks and distrust of personal data protection can be a barrier to adoption of new digital solutions.** When digital solutions, including those provided by governments, do not demonstrate how personal information will be handled and protected, users may opt out. Protection of personal data is an essential element of a digital risk strategy. Digital government efforts should be clearly rooted in and compliant with national data protection regulation to promote trust and user confidence.

(2) **Vulnerabilities can be exploited at any level of the digital public infrastructure (DPI) and beyond.** New digital solutions or platforms should be deployed and tested in the context of the rest of the supporting ecosystem. Hackers have learned to attack systems indirectly, through weaknesses of other elements. This can be at the application level, such as any element of the DPI, or at the national infrastructure level. Some countries, such as the UK, have identified what constitutes their critical national infrastructure (CNI), which they protect with higher priority. Likewise, public finance institutions should identify which elements of their technology stack should be classified as CNI and be protected accordingly.

(3) Emerging technologies offer enticing opportunities, but risks can be challenging to identify and address. For instance, cloud adoption has been critical to the resilience of many countries during the pandemic, but such migration has introduced new opportunities for cybercriminals. Countries are also testing how blockchain and artificial intelligence (AI) can benefit government operations. Proper adoption of emerging technologies requires experts, including cybersecurity professionals, and resources not always available in low- and middle-income countries, and bad actors have taken notice. Responsible and safe innovation can be facilitated with a strong partnership between the private and public sectors, accompanied by progressive regulation (for example, regulatory sandboxes). This would facilitate a faster regulatory response when new threats emerge, as in the case of AI-related risks for example.

(4) **Cybercrimes and online fraud that involve human elements contribute to 80 percent of all data breaches.** Hackers target predominantly users' inexperience with technology to exploit vulnerabilities, typically by enticing them to click a link that may provide unauthorized access. A strong cyber awareness program supported by regular mandatory training for all staff is therefore a critical element of public finance risk management, with significant benefits at relatively low cost. Raising awareness of citizens to foster safer online behavior is a daunting task, which involves engagement of public and private actors, public dialogue, and other coordinated domestic efforts.

(5) **Cybercriminal activities as a result of political and geopolitical relationships have far-reaching consequences for national economies.** The interconnection and availability of mission-critical systems, applications, and services online has contributed to their being prime targets for national- or state-sponsored cyberattackers. The role of revenue administration and customs administration in the national economy has recently made them victims of cyber actors. There are notable criminal activities that cripple national information systems and disrupt business operations. In Costa Rica, business operations were disrupted when the customs administration systems were crippled by a ransomware attack; employees were unable to access paychecks or medical records or track the spread of COVID-19 for more than two months.

(6) **Inadequate procurement of digital solutions can contribute to failure of IT projects.** Procurement of new digital technologies in the government can be lengthy, cumbersome, and possibly inappropriate. Risks include missing a window of opportunity, wasting money, vendor lock-in, or reputational risks. The digitalization of public financial management functions should be accompanied by a modern, well-informed, and agile procurement team.

(7) **Existing gaps and challenges in the implementation of digital solutions impact their effective adoption.** Some gaps and challenges, such as inadequate data governance frameworks, may affect interoperability between systems and databases, data quality, and accuracy. Further, digital ID authentication mechanisms for secure access to services and transactions online are still nascent in many low- and middle-income countries. In some countries, digital ID system rollouts and adoption are very slow where the poor, people living in rural areas, the elderly, and people with disabilities struggle the most.

(8) **The Digital divide and digital exclusion can hinder a portion of the community from using or accessing opportunities presented by digital technologies.** Many governments and businesses can launch new digital services or already have them in place. However, beneficiaries of these services may not be able to take advantage of them. For instance, accessing a digital platform may require a computing device—a smartphone, for example—which a user may not have or cannot afford. The lack of knowledge and skills needed to use technology can be a barrier to using a digital public service system. Unreliable or nonexistent critical infrastructure such as internet or electricity to facilitate access to online services can exclude citizens living in rural areas from accessing government digital services. For instance, 1.1 billion people lack access to electricity and 2.9 billion people, 96 percent of whom live in developing economies, have no access to the internet. The risk of further excluding those who do not have or cannot afford access to digital services should be recognized and mitigated just like any other digital risk.

Adapting during and after disruption

No digital solution is 100 percent susceptible to or free from digital risks such as cyberattacks. It is therefore critical to invest in digitally resilient capability to help public finance organizations rapidly adapt to future disruption, as well as capitalize on future opportunities. This can be achieved in several ways—for example,

(1) Ensuring availability and continuity of public services and delivery: Digital resilience encompasses planning for a business disruption or disaster and building the capability to detect, respond, recover, and thrive, even after disruption. This requires public institutions to identify key digital assets—for example, critical payment systems and national ID systems—that foster social and economic activities to classify them as part of the country's critical infrastructure services. The exercise goes along with identification of and protection against any potential threat (actors) that can destroy or disrupt critical infrastructure or its services.

(2) **Management of cybersecurity incidents and other (cyber) criminal activities requires coordinated trainings and awareness at different levels.** Some countries have put in place mechanisms to deal with cyberattacks at different levels, such as at strategic, operational, and ad hoc levels. Such mechanisms aim to provide security controls either to prevent or detect and respond to or recover from cyberattacks. Users need to be trained regularly to understand their responsibilities in recognizing suspicious (cyber) criminal activities and how to take the appropriate steps in reporting security incidents. Similarly, stricter laws need to be in place and enforced to combat cybercriminal activities and fraud in the digital arena. National community emergency response team, sectoral, and institutional security operations center capabilities can be tapped to monitor the network and detect and respond to cyberattacks. Last, there should be policies and incentives (for universities and the private sector) to produce and retain cybersecurity talent, which is scarce globally.

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