CHAPTER 8

# Using Digital Technology for Public Service Provision in Developing Countries

## Potential and Pitfalls

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Public services are important to a country's productivity, growth, and development.[1] Yet the quantity and quality of public services varies widely, in part due to information asymmetries, high transaction costs, and weak institutions.

As such, one promising trend over the past two decades has been growth in the coverage and adoption of digital technologies, particularly information and communication technologies, especially in remote rural areas (Aker and Mbiti 2010; Aker 2011; Nakasone, Torero, and Minten 2014; Aker and Blumenstock 2014; Aker, Ghosh, and Burrell 2016).

In particular, the spread of mobile phone technology offers new opportunities for rural households to realize a variety of broader development goals. In public service provision, digital technology has the potential to increase citizens' access to public and private information, improve coordination among citizens, facilitate data collection to better allocate public goods, and improve access to financial services, especially through mobile money. In addition, by using digital technology to improve tax design and enforcement, this might increase public funds available for financing public services (Chapters 2 and 13).

Over the past decade, numerous digital public service initiatives have been developed and disseminated by both the public and private sector, with an estimated 400 initiatives deployed worldwide as of 2017.[2] While these initiatives span a variety of countries, sectors, and digital technologies, the majority of these initiatives in developing and emerging countries have been in the agriculture,

[1]Public service provision is defined as the provision of services to promote economic, social, and environmental sustainability.

[2]For prior reviews in economics on digital agricultural services, see Nakasone, Torero, and Minten (2014); Aker (2011); and Aker, Ghosh, and Burrell (2016); in computer science see Parikh, Patel, and Schwartzman (2007).

education, and health sectors (Nakasone, Torero, and Minten 2014; Aker 2011), as well as the social protection and civic education spheres.

A small but growing number of economic studies of these initiatives suggests that impact is mixed. In particular, the research suggests that such initiatives are primarily successful in improving the efficiency of public service provision—in other words, providing a public service of a given quality and quantity at a lower cost—especially in the area of social protection. However, such systems often require substantial fixed costs to build the necessary digital infrastructure, provide the technology to citizens, and develop the necessary platforms.

In other sectors, such as education and civic education, digital public service provision seems to improve the effectiveness of such interventions—that is, ensuring that these programs meet their stated goals, such as improving educational outcomes and increasing voter participation. The results are more mixed, however, in agriculture and health, despite the relatively large number of initiatives in these areas. In addition, much of the research does not seem to focus on whether digital public service provision is improving the coverage of these services or whether public funds are being put to best use. These initiatives also seem to be most successful when they address key information asymmetries and high transaction costs in that market and sector.

What is less often considered in economic research of these initiatives are basic questions of digital technology access and usability. Digital technologies encompass different types of infrastructure, technologies, and platforms, each of which has unique features, as well as different rates of access and usage, especially in remote areas of developing countries. While research in the computer science discipline focuses heavily on how technology can be used and manipulated by poor and low-literate populations (Medhi, Ratan, and Toyama 2009; Patel and others 2010; Wyche and Steinfield 2015; Aker, Ghosh, and Burrell 2016), these factors are less often considered in economics studies of the subject. Yet low uptake or usage of digital public service initiatives could, in part, explain some of the observed null results in economics studies of their impact.

This chapter first reviews the challenges in public service provision, focusing on different types of market failures. It then looks at ways digital technologies can overcome these failures and discusses the types of digital public services disseminated in the past decade, updating recent economics reviews in this area (Aker 2011; Aker and Blumenstock 2014; Nakasone, Torero, and Minten 2014; Aker, Aker, Ghosh, and Burrell). The chapter then reviews existing research of the impact of digital public services on the effectiveness and efficiency of such services, focusing primarily on the agriculture, civic engagement, education, health, and social protection sectors. It closes with a look at the gaps in the design and implementation of these initiatives, before providing suggestions for future research and policy.

This review focuses primarily on lower- and middle-income countries and does not include digital public service provision in high-income countries. Notably, it also does not include the so-called Digital Five—a network of leading digital governments that seek to strengthen the digital economy and the

government's relationship with technology.[3] Also excluded are key digital services such as tax design, collection and enforcement, as well as national identification schemes. These are covered in other chapters of this book. In addition, while this chapter covers the use of digital technology in social protection programs and for salary payments, it focuses on only those programs with rigorous economic research evaluating their impact. Other examples of the use of digital payments are included in Chapter 13.

## PUBLIC SERVICE PROVISION AND ECONOMIC DEVELOPMENT

### The Challenge of Public Service Provision

Public service provision is broadly defined as the provision of goods and services to promote economic, social, and environmental sustainability (World Bank 2005). These goods and services include, among others, electricity, education, emergency services, environmental protection, financial services, health care, postal services, public security, transport, social welfare, and water.[4] Public service provision is often associated with a social consensus that certain services should be available to all, regardless of income. These services can either be provided directly by the public sector or financed by the public sector and outsourced to other service providers (World Bank 2005).[5] Even where public services are not publicly provided or financed, they are often subject to regulation.

Significant economic literature measures the relationship between public services and economic development, showing a positive correlation between the two (Bartik 1991; Wasylenko 1991; Munnell 1992; Fox and Murray 1993). A majority of these studies focus on the impacts of particular public services, such as infrastructure, education and public safety, and show that "some public services . . . have a positive effect on some measures of economic development in some contexts" (Fisher 1997). Of the public services examined, transportation and infrastructure services show the strongest positive relationship with economic growth (Fisher 1997; Donaldson, forthcoming; Dinkelman 2011; Michaels 2008; Duflo and Pande 2007; Jensen 2007; Aker 2010). At the same time, many of these studies focus on a single partial equilibrium result.

[3]The Digital Five include New Zealand, Estonia, United Kingdom, Israel, and Korea.

[4]While access to financial services is required for economic and social development, it is often not directly provided by the public sector, but access and usage is usually regulated or enabled by the public sector.

[5]A number of models can be used in providing public services. These include, but are not limited to, "government provision; managing, funding, and regulating external providers through grants and the purchase of services, including where a market or quasi-market for public services is created (that is, purchaser); subsidizing users to purchase services from external providers; imposing community service obligations on public and private providers; and encouraging individuals and communities to be responsible for their public services and to use mutual aid and philanthropic resources to supplement government funding" (World Bank 2005).

Despite the potential importance of public services for economic growth, stability, and development, the quantity and quality of public services remain limited worldwide, especially in countries with limited resources and weak institutions (Batley, McCourt, and Mcloughlin 2012; World Bank 2005).

In infrastructure, for example, the density of road networks—a key public good for the flow of goods and services—varies widely across and within countries. The lowest density of paved roads in the world is in sub-Saharan Africa, for example; out of 2 million kilometers of roads, only 29 percent are paved (Aker and Mbiti 2010). While it is estimated that 85 percent of the world population has access to electricity, this hides wide disparities across and within countries, ranging from 20 to 80 percent (World Bank n.d.).[6] In sub-Saharan Africa and Southeast Asia, it is estimated that 48 and 32 percent of people do not have access to electricity, respectively (McKinsey & Company 2015).

In education, pupil-teacher ratios—a common indicator of human resource capacity in this sector—have either remained stable or increased considerably in certain regions. In South and West Asia, pupil-teacher ratios have reached 41:1 and 44:1 in sub-Saharan Africa, compared with an average of less than 25:1 in other regions (UNESCO 2014). Yet even in those areas where teachers are present, teacher absenteeism remains a problem. Transparency International (2013) estimated that absenteeism, across 21 developing countries, ranged from 11 to 30 percent. Not only is teacher absenteeism correlated with lower educational outcomes (Duflo, Hanna, and Ryan 2012; Muralidharan and others 2017), but it also accounts for the loss of up to one-quarter of primary school spending in some countries. This amounts to $16 million in Ecuador and $2 billion in India annually, representing 10–24 percent of recurring primary education expenditures in those countries (Transparency International 2013).

In social protection programs worldwide, implementation bottlenecks reduce their effectiveness, but developing countries face particularly high costs (Banerjee and others 2016; Finan, Olken, and Pande 2015).[7] Social assistance programs often represent a significant portion of government spending, between 1 percent and 2 percent of GDP on average, according to the World Bank ASPIRE database. Yet, despite their importance in government spending, these programs are often subject to challenges in targeting, that is, reaching the intended beneficiaries (World Bank 2005; Pritchett 2005). In India, for example, only 15 percent of spending actually reaches the intended beneficiaries by some measures, even though the country spends about 2 percent of GDP on social protection pro-

[6]The World Bank Sustainable Energy for All database is from the Sustainable Energy for All Global Tracking Framework led jointly by the World Bank, International Energy Agency, and Energy Sector Management Assistance Program.

[7]While definitions of social protection programs vary widely, the World Bank's Atlas of Social Protection program (ASPIRE) defines them as publicly funded programs that aim to improve the well-being of targeted populations, especially of the poor, including, but not limited to, conditional and unconditional cash transfers, social pensions, school feeding, in-kind transfers, food and fuel subsidies, fee waivers, and public works (ASPIRE: Indicators of Resilience and Equity).

grams (IPA 2016). Focusing on a subsidized rice distribution program in Indonesia (*Operasi Pasar Khusus*), Olken (2006) found that 18 percent of rice disappeared. In a separate study of a rice subsidy program in Indonesia (*Raskin*, or "Rice for the Poor"), beneficiaries received only about one-third of their intended subsidy (Banerjee and others 2016).

Beyond transfers in-kind—which may seem especially vulnerable to corruption and leakage—cash transfer programs can also be subject to inefficiencies. In India, the Mahatma Gandhi National Rural Employment Guarantee Scheme is one of the largest social protection programs in the world, reaching almost 50 million households in 2013 (Banerjee, Duflo, and others 2016; Muralidharan, Niehaus, and Sukhtankar 2016). The scheme guarantees households 100 days of work per year, typically in unskilled manual labor on infrastructure projects (Banerjee, Hanna, and others 2016). However, a recent study estimated that at least 20 percent of official employment under the scheme was not accounted for in household surveys (Banerjee and others 2016).[8]

The constraints related to access to and quality of public service provision seem to disproportionately affect the poor. For example, Chaudhury and others (2006) found that 19 percent of public primary school teachers and 35 percent of public health care workers were absent in six developing countries, with lower absenteeism in poorer countries and in poorer states. In addition, Olken (2006) found that ethnically heterogeneous and more sparsely populated areas seemed to be disproportionately missing rice.

## Market Failures in Public Service Provision

Politics, poor governance, and weak institutions have become central to explanations of the under-provision and low quality of public services in developing countries (Batley, McCourt, and Mcloughlin 2012). While much of the economics literature on public service provision focuses on the importance of good governance and strong institutions (Batley, McCourt, and Mcloughlin 2012; Finan, Olken, and Pande 2015), it has historically paid less attention to the internal workings of the state and the individuals who provide the public services (Finan, Olken, and Pande 2015). While institutions and personnel economics are crucial in understanding the provision of public services, they are also set within the context of other market failures.

As some public services are pure public goods, the market will fail to provide these goods at optimal levels. This is, in part, due to the non-rivalry and non-excludability of these goods, and hence the free-rider problem. In the context of weak institutions, it is difficult for governments to identify citizens' preferences and willingness to pay for, monitor the provision of, or enforce

[8]Furthermore, demand for employment is often greater than supply: in Bihar, an estimated 77 percent of households wanted but could not find Mahatma Gandhi National Rural Employment Guarantee Scheme work in 2009–10.

taxation to raise funds for these goods, which, in turn, undermines their efficient allocation.

Even if a public service is not a pure public good, some public services may have public goods properties, such as health, education, and some infrastructure, and therefore generate positive and network externalities (Besley and Ghatak 2006).[9] If these externalities are not internalized by the market, then, similar to the public goods problem, these services will not be provided at optimal levels.

In theory, public services can be provided by the public or private sector, as long as there are no transaction costs and strong informational assumptions are met (Coase 1960). Yet public service provision is often plagued by imperfect information. For example, given long distances to remote rural areas, limited budgets, and poor infrastructure, governments often have a difficult time monitoring public sector employees, which can lead to corruption, absenteeism, and poor performance. These problems may, in fact, be further exacerbated by the nature of public sector employment contracts, which may make it difficult to provide incentives to or sanction employees who are consistently underperforming (Finan, Olken, and Pande 2015).

These information constraints also affect citizens' knowledge about the location of public services and their quality, where to find these services, whether they are eligible to receive such services, and how best to use them. This can further affect the efficient provision of public services, as well as citizens' ability to provide feedback on their allocation and quality (World Bank 2016).

Yet, imperfect information can also affect governments' ability to finance the provision of public services. As mentioned above, if governments are unable to identify consumers' preferences and willingness to pay for such services, it can be difficult to determine their optimal provision. This, in turn, makes it more challenging to design tax schemes to fund public goods. Even if consumers' preferences could be revealed, an additional question is whether tax schemes could be effectively enforced, thus further reducing the financing mechanisms available to finance public goods.

Finally, some public services may have few service providers, either in the public or private sector. While this may be optimal in markets with economies of scale or high entry costs, in the absence of appropriate regulation, this can also lead to higher prices, lower quantities, and lower-quality services.

The next section outlines some of the ways in which digital technology can address some of these market failures and the mechanisms through which it may improve the provision of public services.

[9]Only some parts of the health, education, and infrastructure sectors have substantial public goods components. For example, the distribution of electricity may have important network externalities, whereas electricity generation may not necessarily be a public good. Interventions such as clean water and vaccination have much stronger public goods components than some curative treatments (Besley and Ghatak 2006).

## THE POTENTIAL FOR DIGITAL IN PUBLIC SERVICE PROVISION

### Digital Coverage and Adoption

Despite constraints in public service provision worldwide, digital infrastructure—including the internet, mobile phones, and other tools that can be used to collect, store, analyze, and share information digitally—has increased substantially over the past 15 years (World Bank 2016). Between 1999 and 2014, the percentage of people with access to mobile phone coverage grew from 10 percent to 90 percent (ITU 2014; GSMA 2013). Mobile phone coverage has expanded rapidly in Africa, Asia, and Latin America, from largely non-existent networks at the turn of the century to a point where over 70 percent of the population of sub-Saharan Africa is covered by the mobile network (GSMA 2013; Aker and Blumenstock 2014).[10]

This expansion in mobile network coverage has corresponded with increases in mobile phone adoption and usage (Aker and Mbiti 2010; Aker and Blumenstock 2014). According to the World Bank's 2016 *World Development Report*, more households in certain regions own a mobile phone than have access to electricity or clean water, and approximately 70 percent of the poorest populations in developing countries own a mobile phone (World Bank 2016).[11] In sub-Saharan Africa alone, approximately one-third of the population has an active mobile phone subscription (GSMA 2013). In addition, over half of the world's mobile-broadband subscriptions are based in developing countries, with coverage rates in Africa reaching close to 20 percent in 2014 (ITU 2014; Aker and Blumenstock 2014).

In addition to mobile phone coverage, the number of internet users has increased significantly, from 1 billion users in 2005 to an estimated 3.2 billion users at the end of 2015 (World Bank 2016). Nevertheless, while internet access and smartphone penetration have grown substantially in many developing countries, disparity remains wide across and within countries. Smartphone usage is still primarily concentrated in urban, wealthier, and more highly educated populations in these countries.

[10]As the growth of mobile telephony has been driven largely by the private sector, this growth has not been uniformly accessible to all segments of society, and was initially skewed toward a wealthier, educated, urban, and predominantly male population (Aker and Mbiti 2010; Aker and Blumenstock 2014).

[11]Growth of the worldwide subscriber base is fastest in developing countries, with "four out of five new connections being made in the developing world, and 880 million unique developing-market subscribers estimated to register new accounts by 2020" (GSMA 2013). As of 2009, over two-thirds of the population of Asia and three-quarters of the population of Latin America had access to mobile phone coverage (Aker and Blumenstock 2014). Roughly 55 percent of the world's 2.3 billion mobile-broadband subscriptions are also based in developing countries, with coverage rates in Africa reaching close to 20 percent in 2014, as compared with 2 percent in 2010 (ITU 2014; Aker and Blumenstock 2014).

## The Potential for Digital in Public Service Provision

In remote rural areas, digital technology—primarily mobile phone networks—has often represented the first access to digital infrastructure (Aker and Mbiti 2010; Aker and Blumenstock 2014). While each type of digital technology has unique features, this section focuses on one type of digital technology: simple mobile phones. This is primarily because simple mobile phones are still the most ubiquitous digital technology by coverage and adoption, especially in rural areas of developing countries, which often have the lowest access to public services.[12]

Broadly speaking, simple mobile phone technology has two primary functions: for communication (voice, messaging) and for money transfers. As a communication device, mobile phone technology reduces the cost of communicating, improving the circulation of information within a person's social networks ("private" information) (Aker and Mbiti 2010; Aker and Blumenstock 2014; Aker, Ghosh, and Burrell 2016). It also facilitates the dissemination of "public" information (that is, information that is provided through the government, non-governmental organizations, and firms). With the introduction of mobile money and other digital financial services, mobile phones can also allow consumers and firms to more easily access financial services, such as money transfers, input vouchers, commitment savings, and credit (Aker and Mbiti 2010; Aker and Blumenstock 2014; Aker, Ghosh and Burrell 2016).

As communication devices, simple mobile phones have greatly reduced the cost of communicating over long distances, allowing individuals to communicate with each other more frequently (Aker and Mbiti 2010). Relative to personal travel, the transport and opportunity costs of using a mobile phone are significantly cheaper (Aker 2010; Aker and Mbiti 2010; Aker and Blumenstock 2014; Aker, Ghosh, and Burrell 2016). From the government's perspective, mobile phone technology can reduce the cost of disseminating crucial information.[13] In Niger, for example, replacing an extension agent's field visit with one digital interaction (that is, an SMS or a phone call) reduced the communication costs by half (Aker 2010).

In addition, simple digital technology can reduce the cost of collecting, processing, and disseminating information, especially compared with traditional survey methods used by government agencies (Aker 2010; Aker and Blumenstock 2014; Aker, Ghosh, and Burrell 2016). This can take the form of simple phone or SMS surveys, as well as "big data" on voice, SMS, and mobile money transactions (Blumenstock 2016).

The launch of mobile money services—which allows individuals to transfer stored value on their phone—significantly reduces the cost of transferring money

[12]In theory, more advanced digital technologies—such as computers, laptops, and smartphones, which have access to the internet and other features—would offer additional possibilities for addressing some of these market failures.

[13]If information is shared by a public or private sector "clearinghouse," this can, in turn, allow governments to share information more widely and more quickly.

compared with other means (Aker and Mbiti 2010; Aker and Blumenstock 2014). This cost reduction can, in turn, allow individuals to transfer money more easily, potentially increasing the frequency and amount of transfers received and allowing households to smooth consumption in the face of shocks (Jack and Suri 2014; Aker and Blumenstock 2014; Blumenstock and others 2016). As discussed in other chapters of this book, mobile money can therefore reduce the costs associated with implementing public transfer programs or salaries, as well as encourage new financial providers to enter the public service space, especially as the costs of providing these services can be cheaper.

Mobile money can also potentially be used as a secure place to save (Mas and Mayer 2012; Aker and Wilson 2013; Aker and Blumenstock 2014). Since the mobile money "account" is protected by a user password, m-money might offer greater security than at-home savings mechanisms, improving access to emergency savings or encouraging individuals to save for particular objectives (Aker and Blumenstock 2014).

How can these features of digital technology—even the simple mobile phone—address market failures in public service provision?

In *information*, these cost reductions can improve citizens' access to public and private information (Aker and Blumenstock 2014; Aker, Ghosh, and Burrell 2016), which can make markets more efficient and lead to net welfare gains. This reduction in search costs should, in theory, allow market actors to search more quickly and over a broader geographic area, in a wide variety of domains—education, health, and agricultural prices (Aker and Blumenstock 2014). These cost reductions also facilitate increased and more timely contact with members of one's social network, as well as promote better access to both public and private information (Aker 2010; Aker and Blumenstock 2014; Aker, Ghosh, and Burrell 2016).

Mobile phones also offer a promising and cost-effective method for the dissemination of public or quasi-public information, such as a public or private sector "clearinghouse," which can, in turn, allow governments to share information on public goods (Aker 2010; Aker and Blumenstock 2014; Aker, Ghosh, and Burrell 2016). This can also help to address the moral hazard problem associated with monitoring public sector agents, by allowing governments to more easily contact employees or collect data on absenteeism. In addition, digital technology can provide educational services for public sector employees and citizens at lower cost and greater outreach than traditional programs (Aker and Blumenstock 2014).

In public goods provision, digital data collection can allow governments to get better access to citizens' preferences for public goods—such as through digital surveys, which can allow automation of routine activities (World Bank 2016, 2017). At the same time, it can also improve citizens' involvement in and engagement with those public goods, potentially improving provider accountability (Aker and Blumenstock 2014; World Bank 2017).

Increased access to digital services and information-sharing can also increase citizens' social learning from their peers, which could speed up the adoption process of other public services.

And finally, with public-private partnerships, as well as the involvement of the private sector in public service provision, digital technology can encourage new service providers to come into this space, potentially addressing imperfect competition.

Thus, even simple digital technology could improve public service provision by (World Bank 2016):

- "Enabling governments to replace some factors used for producing services through the automation of routine activities, particularly discretionary tasks vulnerable to rent-seeking, such as social protection programs" (World Bank 2016); and
- Overcoming information barriers, which can improve monitoring (both by citizens through regular feedback on service quality and by governments through better management of government workers) and citizen coordination (World Bank 2016).

In particular, digital technology could improve the effectiveness of such services by allowing public service programs to better meet their stated goals and improve the efficiency of such services by ensuring that they are being delivered in a least-cost manner for a given quantity and quality. It could also improve coverage of such services by ensuring that they are being expanded with appropriate partnership or contractual relationships within and beyond government as well as ensure that they are providing "money's worth" by helping to assess whether the public funds are being put to best use. These potential impacts are, of course, affected by the existing market failures associated with public service provision and the strength of institutions within a given context.

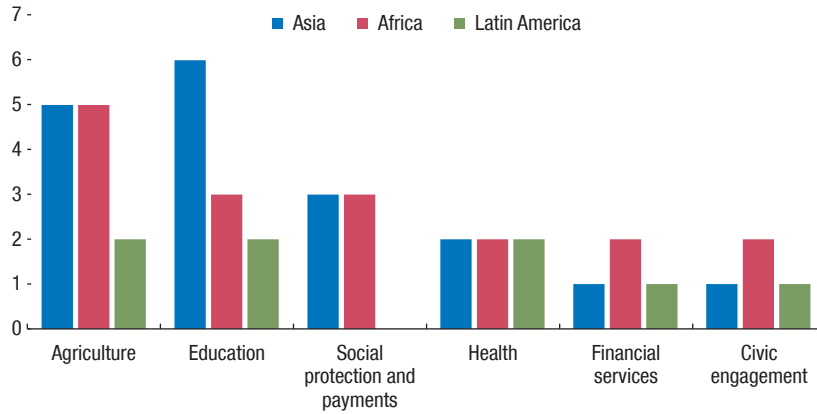
## DIGITAL PUBLIC SERVICE PROVISION: PRACTICE AND EVIDENCE

Overall, it is estimated that there are more than 400 digital public service programs worldwide, in a variety of contexts, digital forms, and sectors (GSMA m-Agri deployment tracker; GSMA m-Health deployment tracker; Aker, Ghosh, and Burrell 2016).[14] These are implemented by governments, non-governmental organizations, the private sector, and public-private partnerships. These programs span public services in sectors including agriculture, civic education, education, environment, health, financial services, social protection, and utilities. In addition, they use a variety of digital technologies, from computers to mobile phones to radios to smartphones (Aker, Ghosh, and Burrell 2016).[15]

[14]These estimates are based upon GSMA's database of m-agriculture, m-health, and mobile money deployments, as well as the author's own research on specific digital initiatives and economic research in this area.

[15]More broadly, "Digital government is defined as the optimal use of electronic channels of communication and engagement to improve citizen satisfaction in service delivery, enhance economic competitiveness, forge new levels of engagement and trust, and increase productiv-

**Figure 8.1. Number of Research Studies on Digital Public Services, by Region and Sector**




Source: Author's calculations.

Despite the proliferation of digital public service programs, only a fraction of these are being researched. For this chapter, we identified 44 studies across 17 countries, primarily focusing on studies in developing countries or emerging markets and those using rigorous impact evaluation methodologies.[16] A majority of studies take place in Asia and Africa, with many in Asia focusing on India. Across all different types of public services, the studies are primarily focused on certain sectors, namely, agriculture, education, health, social protection, and civic education (Figure 8.1).

While the impacts of these initiatives depend upon the sector, the technology, and the context, in general, digital service provision seems to have a positive impact on the effectiveness of certain public services, such as education, social protection, and civic education. In social protection, studies have shown that digital systems are often more efficient, as they have lower costs of implementation, despite high initial fixed costs. Few studies are designed to measure the impacts of digital technology on the coverage of these public services or "money's worth"—that is, whether public spending should be spent in another sector or area.

ity of public services. A digital government encompasses the full range of digitalization—from the core digitalization of public services to the digital infrastructure, governance and processes, including both front- and back-office transformation needed to deliver the new service paradigm" (Accenture 2014).

[16]This includes impact evaluation studies that use both experimental and non-experimental approaches. The 44 studies discussed in this chapter may not be representative of all academic or other studies in this field. This review excludes key studies in other areas, such as tax collection and national identification schemes covered in other chapters of this book.

## Education[17]

In education, digital technology has primarily been used for one of two purposes: as a pedagogical tool in the classroom and as a tool for monitoring teacher attendance. Overall, most studies of the impact of digital technology as a pedagogical tool suggest that digital technology improves student learning in the short term, but that these impacts diminish in the medium term. Studies in digital monitoring suggest that these programs improve teacher attendance and improve learning outcomes, where they are measured.

Substantial literature assesses the impact of digital technology on learning outcomes, with most of these studies focusing on computers and laptops in primary and secondary schools. While a majority of these studies find that computers have positive effect on student learning outcomes (Banerjee, Cole, and others 2007; Linden 2008; Lai and others 2015; Yang and others 2013; Lai, Khaddage, and Knezek 2013; Mo and others 2014), some find no effects (Barrera-Osario and Linden 2009; Beuermann and others 2015) or negative effects (Linden 2008; Malamud and Pop-Eleches 2011). Yet, few of these studies measure the impacts upon learning outcomes in the longer term, except Banerjee and others (2007).[18]

Focusing on mobile phones as a pedagogical tool for adults, Aker, Ksoll, and Lybbert (2012) conducted a randomized control trial (RCT) in Niger, where a mobile-phone-based component was added to an otherwise standard adult education program. Overall, the authors found that the mobile phone technology substantially improved adults' writing and math scores in the short and medium term, and led to other improvements in household well-being (Aker, Ksoll, and Lybbert 2012; Aker and Ksoll 2017). While the digital approach was not more efficient, as it was more expensive than the traditional program, it was more cost-effective. Aker and others (2014) found similar results for a mobile-phone-administered adult education program in Los Angeles.

In digital monitoring, Duflo, Hanna, and Ryan (2012) find that interventions that use cameras and financial incentives reduce teacher absenteeism and increase children's test scores. In Uganda, Cilliers and others (2016) find that mobile phone monitoring and financial incentives in Uganda improve teacher attendance, primarily when there are financial incentives; however, they do not measure impacts on learning outcomes. And finally, using mobile phones to monitor adult education teachers in Niger (without financial incentives), Aker and Ksoll (2017) find that monitoring increases students' learning outcomes, but primarily in the short term.

[17]This section excludes many of the studies included in paper by Escueta and others 2017, which focuses on the use of digital in education for developed countries and which was released in August 2017.

[18]These include Linden (2008); Barrera-Osario and Linden (2009); Banerjee and others (2007); Barrow and others (2009); Malamud and Pop-Eleches (2011); Lai, Khaddage, and Knezek (2013); Beuermann and others (2013); Fairlie and Robinson (2013); and Carrillo, Onofa, and Ponce (2010).

## Social Protection

In general, digital technology has been used in social protection in one of two ways: as a mechanism for implementing such programs, either through digital national identification schemes or electronic income transfers; or as an alternative means for targeting potential beneficiaries of such programs, primarily through big data. While there are a number of initiatives in this area, existing studies suggest that digital can reduce the costs associated with implementing these programs, allowing the public sector to provide these transfers at a lower cost.

In one of the first studies of a digital social protection program, Aker and others (2016) used an RCT to measure the impact of using mobile money to distribute cash transfers in Niger. They found that mobile money reduced the implementing agency's costs of disbursing the transfers and program recipients' costs of obtaining those transfers as compared with the manual cash transfer program. In addition, program recipients who received the transfer through m-money used the transfer to purchase more diverse food items and had higher diet diversity. Nevertheless, there were substantial fixed costs to setting up the digital transfer distribution system and there were no impacts on leakage, which has been a primary justification for many of these programs.

Using a different digital technology—biometrically authenticated payments infrastructure ("Smartcards")—Muralidharan, Niehaus, and Sukhtankar (2016) measured the impact of this digital infrastructure on two social protection programs in India. Using an RCT, they found that the new system delivered faster and less corrupt payments without adversely affecting access to the program (Muralidharan, Niehaus, and Sukhtankar 2016). The investment was cost-effective as well, as beneficiaries' time was equal to the cost of the intervention. There was also a significant reduction in leakage.

Finally, Banerjee and others (2016) assessed the impact of a digital program that linked the flow of funds to expenditures in the context of a social protection program in India. They found that the new system reduced program expenditures without a concurrent decrease in employment or wages, suggesting that increased transparency reduced leakage (JPAL 2016). The policy did not have an impact on beneficiaries' employment or wages (JPAL 2016).

Outside of the use of digital technology to implement social protection programs, digital data—such as mobile phone records—have been used as an alternative means of targeting the poor (Blumenstock and others 2015; Blumenstock 2017). While these studies have not been used for targeting in an existing social protection program, Blumenstock and others (2015) and Blumenstock (2016) show that an individual's mobile phone use can be used to infer socioeconomic status, and a population's mobile phone data can be used to reconstruct the distribution of wealth within a nation.

Yet beyond the use of big data for targeting, mobile phones can also be used to collect remote and more frequent data for social protection or other development programs (Dillon 2012; Aker 2011). For example, mobile phones can be

used to collect more frequent data from households, either as a complement or substitute for in-person surveys, which often occur annually (Dillon 2012).

## Civic Education

In civic education, digital technology has been primarily used in one of three ways: (1) providing more frequent transmission of information between citizens and the state, often during elections; (2) verifying polling results digitally during elections; and (3) digitalizing electoral ballots. Overall, these studies have found that digital approaches have effectively increased voter participation during elections and reduced fraud.

While numerous studies assess the impact of the provision of civic information on voter participation and electoral outcomes (Gine and Mansuri 2011; Banerjee and others 2011; Chong and others 2015; Humphreys and Weinstein 2012), studies on the provision of civic information digitally—especially in developing countries—are more recent (Dale and Strauss 2009). Using an RCT during the 2009 elections in Mozambique, Aker, Collier, and Vicente (2017) found that the provision of civic education through SMS, as well as a mobile phone hotline to report electoral fraud, increased voter turnout and reduced voter fraud.

In electoral monitoring, an RCT that introduced a simple camera-phone-based intervention that photographed election return forms at polling centers in Afghanistan substantially reduced fraud (Callen and Long 2015; World Bank 2016). A similar experiment during the 2012 elections in Uganda decreased the vote share for the incumbent, the candidate most likely to benefit from voter fraud, and decreased other measures of fraud (Callen and others 2016; World Bank 2016). In Brazil, the introduction of the digital ballot in the 1990s increased voter participation—especially for low-literate populations—and reduced voter fraud (Fujiwara 2015; World Bank 2016).

## Agriculture[19]

Digital technology in the agricultural sector has primarily been used in three ways: (1) to provide information to farmers about agricultural techniques, prices or weather; (2) to provide agricultural extension advice; and (3) to monitor agricultural extension agents (Aker, Ghosh, and Burrell 2016). Overall, studies on digital agriculture initiatives suggest that such services increase farmers'

[19]This section draws heavily on Aker, Ghosh, and Burrell (2016). It excludes research on the impact of information technology on the private provision of information, that is, in which farmers, traders, and other actors share information privately through digital technologies, rather than an external platform. Overall, that body of evidence suggests that access to mobile phone coverage and usage can improve farmers' and traders' access to information and market performance. Several studies have found that mobile phone coverage is associated with improved agricultural market efficiency, as defined as a reduction in price dispersion across markets (Jensen 2007; Aker 2010; Mittal and others, 2010; Aker and Fafchamps 2015), but with mixed impacts on farm-gate prices (Aker and Fafchamps 2015; Mitra and others 2015; Futch and McIntosh 2009).

knowledge in particular areas—such as prices and cropping systems—but have little to no impact on agricultural practices, production, or farm-gate prices.

In digital agricultural information, there is a significant body of research in sub-Saharan Africa, India, and Latin America. In Uganda, an RCT that assessed the impact of providing market prices through the radio found that the intervention increased farmers' prices and maize sold (Svensson and Yanagizawa 2009; Aker, Ghosh, and Burrell 2016). Yet other studies on the impact of digital market price information and weather systems were more mixed: while two studies found that digital information systems increased prices, others found no effects (Aker, Ghosh, and Burrell 2016; Courtois and Subervie 2015; Hildebrant and others 2014; Nakasone 2013; Mitra and others 2015; Camacho and Conover 2011; Fafchamps and Minten 2012). Yet the introduction of internet kiosks that provided price information and quality testing in India had a positive effect on soybean prices and production (Goyal 2010).

In digital agricultural extension advice, using a RCT in India, Cole and Fernando (2016) found that mobile-phone-based agricultural extension information encouraged farmers to invest more in recommended agricultural inputs and increased cumin and cotton yields (Aker, Ghosh, and Burrell 2016). In Kenya, an RCT of an SMS-based extension information system found that the system increased sugar cane yields, but these results were not sustained beyond the first year (Casaburi and others 2014).

In digital monitoring, Jones and Kondylis (2014) used an RCT to test the impact of different feedback mechanisms for agricultural extension providers (Aker, Ghosh, and Burrell 2016). While both in-person and digital monitoring interventions were equally effective, the digital services were substantially cheaper, suggesting it is a more cost-effective way to obtain such feedback.

## Health

While digital technology in the health sector has been used in a variety of ways—for medical devices, recordkeeping, and providing information and reminders—the majority of studies in developing countries has been in the latter area. Similar to digital agriculture interventions, these studies have found that digital technology is associated with improvements in knowledge, with mixed evidence on behavioral change and other health outcomes.

The use of SMS to provide health-related information has increased substantially over the past decade (Akerlof 1991; O'Donoghue and Rabin 1999, 2001; Frederick, Loewenstein, and O'Donoghue 2002; Banerjee and Mullainathan 2008, 2010; Bandiera, Barankay, and Rasul 2005; Duflo 2012). While some studies found that sending mothers SMS improved breastfeeding practices (Jiang and others 2014; Flax and others 2014), a systematic review of interventions that used SMS to encourage drug adherence found mixed results (Nglazi and others 2013). In sexual and reproductive health, several studies have found that the provision of reproductive health information in public schools led to behavioral

change, lower sexually transmitted disease prevalence, and lower self-reported pregnancy rates (Chong and others 2013; Rokicki and others 2017).

### Putting It All Together

While the studies included above include only a subset of digital public service initiatives, particularly those in developing countries and emerging markets, there are several key findings. Across all sectors and countries, digital service provision seems to improve the effectiveness of these interventions, defined as the likelihood that a particular intervention helps to meet a stated goal.

This is particularly the case in the education, social protection, and civic education sectors. For example, in education, digital technology has helped to improve educational outcomes, at least in the shorter term. In social protection, digital technology increased the likelihood that program recipients received their transfers in a timely manner.

Finally, in civic education, digital technology increased voter participation and reduced voter fraud in elections. However, in the health and agriculture sectors, while digital technology often improved beneficiaries' access to information, impacts upon other outcomes—in terms of either behavioral change or welfare—were more mixed.

In the area of efficiency—defined in this chapter as providing a public service at a lower cost than the status quo—the impact of digital technology is also more mixed. While the provision of information digitally in the agriculture, health, and civic education sectors is, on average, less expensive than traditional means of providing this information, these initiatives are not necessarily always more cost-effective, with the exception of the civic education sector. In education, digital approaches are often more expensive than the traditional means of providing educational services. But they are also more cost-effective, as they result in better outcomes for the same cost. And for social protection programs, there are large efficiency gains: of the three digital social protection programs studied, the variable costs of providing such programs were lower than the alternative, although this often meant large fixed costs for setting up the systems.

Two other criteria often used to assess public service provision are coverage and value for money; in other words, whether public services are provided to the broader population, even in remote rural areas, and whether public funds are being put to their best use. For these two criteria, the evidence is less informative, as most of the studies included in this chapter do not explicitly assess either of these measures.

## THE POTENTIAL PITFALLS OF THE DIGITAL PROVISION OF PUBLIC SERVICES

Despite the potential of digital technology to improve the effectiveness, efficiency, and coverage of digital services in developing countries, there are potential pitfalls in the use of digital for public service provision.

A primary consideration is the type of the digital technology that can be used; that is, the infrastructure, the device (that is, computer, smart phone, mobile phone), the platform (SMS, voice, USSD), and the interfaces (Aker, Ghosh, and Burrell 2016). While smartphones offer new opportunities in many countries, they also add new challenges and costs, and are not yet widely adopted in most rural areas (Aker, Ghosh, and Burrell 2016). Simple mobile phones are widely adopted, but SMS holds limited information and requires some ability to read, and voice platforms can be costly. While digital public service provision can rely upon higher-tech options, understanding the costs associated with building such infrastructure, as well as the constraints to adoption and usage by the targeted populations, is important.

A key assumption of using digital for public service provision is that it will help to overcome key market failures for poor rural populations—namely, imperfect information and high transaction costs (Aker, Ghosh, and Burrell 2016; Aker and Blumenstock 2014). While these are relevant assumptions in most contexts and for most public services, digital technology will only be successful in increasing knowledge, lowering transaction costs, changing behavior, and improving outcomes if a number of necessary conditions exist.

Focusing on information asymmetries, for digital technology to have an impact on knowledge, behavioral change, and other welfare outcomes, information must be a constraint in a given market context. One potential explanation for the weak and mixed results of digital for agriculture and health initiatives may be that such initiatives are not providing relevant, high-quality, and timely information for the intended users (Aker, Ghosh, and Burrell 2016).

Even if digital technology addresses the key market failures of imperfect information and high transaction costs, citizens still need access to other public goods, financial services, and institutions to translate those cost reductions into action. For example, in the area of agriculture, several research papers have noted farmers' limited bargaining power, which limits the potential effectiveness of providing information (Nakasone, Torero, and Minten 2014). Similarly, if farmers do not have access to credit markets, this can limit their capacity to meaningfully use any information provided digitally (Srinivasan and Burrell 2013; Casaburi and Reed 2014; Aker, Ghosh, and Burrell 2016). And finally, if digital technology is used to monitor public service agents, but there are no incentives or sanctions associated with that monitoring, this can limit their effectiveness.

Clearly, a number of digital deployments exist worldwide, yet economic research on these initiatives remains relatively limited and concentrated in particular areas. While such programs may lead to net welfare improvements, it is not always clear that they will improve the welfare of targeted populations. Additional research into these initiatives is needed, using a combination of experimental and non-experimental techniques, comparing the digital intervention with the standard approach (Aker 2011; Aker, Ghosh, and Burrell 2016). As part of this research, it will also be important to think about the cost-effectiveness and efficiency of such interventions, both from the institutional (government) and beneficiary perspective. This is particularly important for low-income users; although

the service may be provided more cheaply using information technology, it may also result in additional expenses costs.

## THE WAY FORWARD

Overall, digital technology offers opportunities to increase access to information, reduce transfer costs, and automate certain tasks, with multiple programs being piloted worldwide. While existing evidence suggests that digital technology can improve efficiency and effectiveness, especially in particular sectors, this is a fraction of what we need to know in this area, and many of these results are often partial equilibrium results. In addition, while digital technologies can improve the effectiveness and efficiency of public service provision, this may not necessarily translate into macroeconomic growth or stronger institutions. And finally, as these technologies are used, understanding the existing market failures—as well as the existing digital technology infrastructure and usage—is key to thinking through their potential impacts and pitfalls.

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