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The Use of Digital for Public Service Provision in Sub-Saharan Africa*

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Accessible, affordable and qualitative public service[2] delivery is critical for the well-being of populations living in developing countries and for the functioning of their economy, but these services are often undermined by market imperfections and weak institutions (Aker, 2017). In light of these challenges, the digitalization process observed in many low and middle-income countries, resulting from the sustained growth in the coverage of mobile networks and the concomitant reduction in information and communication technologies[3] (ICTs) usage gap opened up economic opportunities and helped leapfrog a number of development obstacles, especially in remote rural areas (Aker and Mbiti, 2010; Aker 2011; Aker 2017). ICTs, more particularly broadband Internet and mobile technologies have the potential to become general-purpose technologies (Bresnahan & Trajtenberg, 1995) called upon to play an increasing role in the development process in Sub-Saharan Africa (SSA), including West Africa.

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2. According to Aker (2017, p.201): "Broadly is defined as the provision of services to promote economic, social and environmental sustainability".
3. Information and communication technologies (ICTs) encompass the different types of platforms by which information flows and communications are made (mobile phones, smartphones, computers, tablets, radios, pagers/beepers, etc.), the different functions enabled by these platforms (communications, information dissemination, information collection, information processing), and the various types of content transmitted through them (calls, text messages, emails, websites, videos, radio broadcasts, radio messages, etc.).

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... /... By contributing to the emergence and dissemination of innovations in various sectors such as education, health, utilities, agricultural extension, financial services, and other sectors, the bourgeoning digitization of economies in SSA has raised the prospects of growth, employment and poverty reduction in the region (Aker & Mbiti, 2010; Andrianaivo & Kpodar, 2011; World Bank, 2016; Aker, 2017; Hjort & Poulsen, 2019).

However, throughout Sub-Saharan Africa as a whole and in West Africa in particular, the expected dividends of digital technologies have been slow to materialize and have fallen short of benefitting the whole population (World Bank, 2016). These low digital dividends are explained by a large multidimensional digital divide, induced by the poor spatial coverage of telecommunications and energy infrastructures, especially in rural areas, by low literacy and numeracy rates in many communities, and by the unaffordability of Internet-related services for the majority of the population. Yet, despite these obstacles to ICT penetration, numerous digital public service initiatives – including mobile money – have built on the large adoption of the mobile phone and have spread over the region. In 2017, amongst the approximately 400 digital initiatives deployed worldwide, more than half were located in SSA (GSMA, 2019a; Briter Bridges, 2019), covering a variety of sectors, especially in the areas of agriculture, education, and health sectors and in social protection (Aker, 2011, 2017; Aker & Blumenstock, 2014).

Empirical researches on the consequences of digitalization in these sectors suggest that digital interventions or innovations have generally yield positive economic and social outcomes. In sectors like agriculture, digital public service provision such as digital agricultural extension programs have seemed to improve the efficiency of agricultural markets. Results are more mixed, however, in the area of education, despite the relatively large number of initiatives in these sectors. In the health sector, the emergence and diffusion of innovations such as mobile health (mHealth) have contributed to foster health systems' functioning and inclusiveness, by promoting health behaviors and facilitating health worker's interventions. Overall, although many digital innovations have been successfully deployed in SSA, there are structural obstacles to scaling up, which as of yet have precluded digital technologies from playing their intended role of "engines of growth" (Bresnahan & Trajtenberg, 1995).

Digitization and public services provision in Sub-Saharan African economies: general background

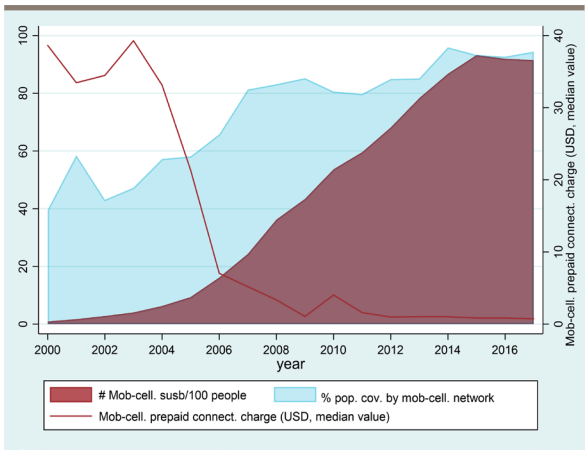
Goldfarb and Tucker (2019) define digital technologies as "the representation of information in bits […] rather than atoms", which "reduces the cost of storage, computation and transmission of data". This definition depicts digital technologies as a type of ICTs with a strong cost-reduction potential. This capacity to reduce various types of cost – information, travel, tracking, and replications costs – makes digital technologies "enabling technologies" (Bresnahan & Trajtenberg, 1995), offering solutions when the provision of public services is undermined by transaction costs and informational asymmetries (Aker, 2017). In some areas of public services, digital technologies have indeed the potential to bypass infrastructures, processes, administrations, institutions that have been put in place and gradually evolved in industrialized countries to reduce these market failures, but which are missing or failing in low-income countries. This potential, however, greatly depends on ICT adoption and diffusion throughout the population.

In SSA, populations excluded from public service provision are usually the same populations that are deprived from access to ICTs; consequently,

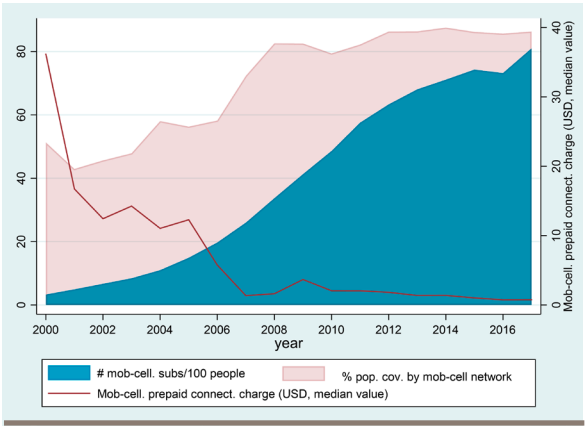
ICT-based public service provision interventions which fail to account for the various dimensions of the digital divide may miss their intended target populations. However, as shown in Figure 1, the diffusion of mobile devices throughout the African population has been spectacular since 2000, in the same way as was the share of the population covered by mobile networks. This period also experienced a marked decrease in the median charge for mobile prepaid connections. In West Africa, mobile penetration and coverage followed a slightly higher pace of progression than the rest of SSA, despite a later decline in mobile phone prepaid tariffs. Overall, in 2016, more than 80% of the population across the region was covered by a mobile network, almost all Africans owned a mobile phone device, and the median mobile prepaid connection charge was below $1.00 US.

Figure 1: Mobile phone penetration in West Africa and SSA

West Africa



Rest of SSA

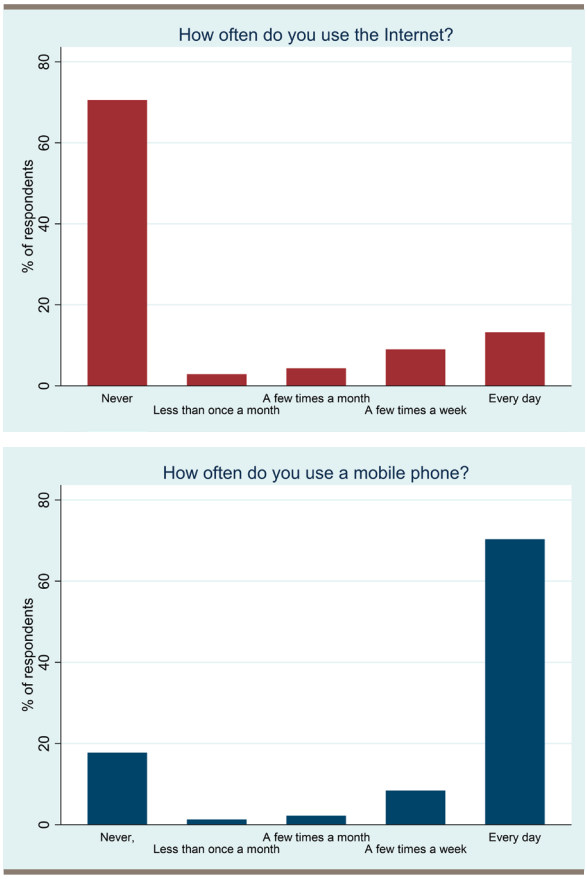


Source: Authors, from ITU dataset. West Africa encompasses ECOWAS countries.

However, Internet penetration rates across African countries were not exceeding 55% of the population in 2015 (ITU, 2019). South Africa, Kenya, Angola, Sudan, Nigeria and Ghana were in the highest penetration rate quintile, with Internet penetration rates lying between 21% and 54% percent of the population. Internet penetration in Francophone landlocked countries is even lower, that is, not exceeding 7% of the population; and among West African countries, Niger, Sierra Leone, and Guinea-Bissau had penetration rates lower than 3.6 percent of the population (ITU, 2019).

Looking at Internet and mobile phone adoption behaviors within the African population, Afrobarometer surveys conducted over a sample of some 50,000 African citizens in 2014 and 2015 in 32 SSA countries stress that the pattern of frequency in Internet use is the exact opposite of mobile phone use (Figure 2). In fact, while 70% of respondents reported never having used the Internet, only 13% of the same respondents reported never having used a mobile phone. By contrast, only 18% of respondents reported using the Internet on a daily basis, while 70% of them declared using a mobile phone every day.

Figure 2: Frequency of internet and mobile phone usage in SSA

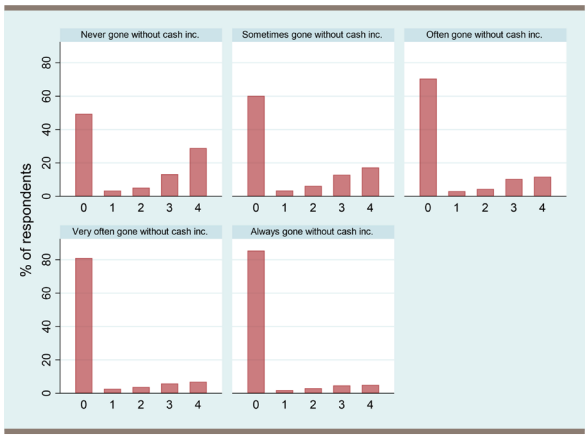


Source: Afrobarometer, 6th round. Sample: 48,283/48.966 respondents (left/right-side graphs). Surveys conducted in 32 SSA countries between 2014 and 2015. Sample weights are applied.

In SSA, important differences in access to digital technologies, especially Internet technologies, can be observed across sub-populations. This heterogeneity is explained by demand-side factors, including literacy and numeracy skills necessary to use digital technologies, but also supply-side factors, such as telecom or energy infrastructure coverage. As a result, the Internet divide is not only related to income (Figure 3) but to various other dimensions of poverty: geography, gender, or education level (Figure 4).

Figure 3: Cash income and the internet divide

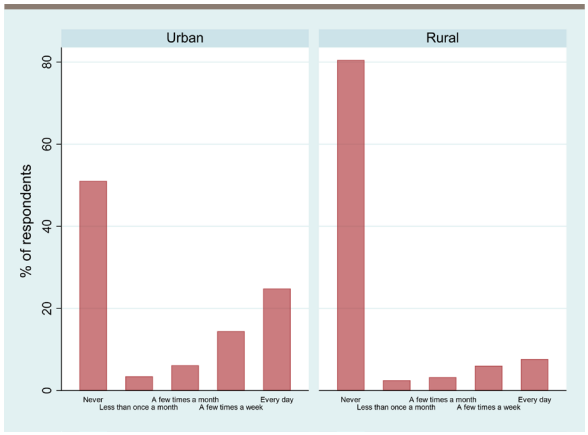
How often do you use the Internet?



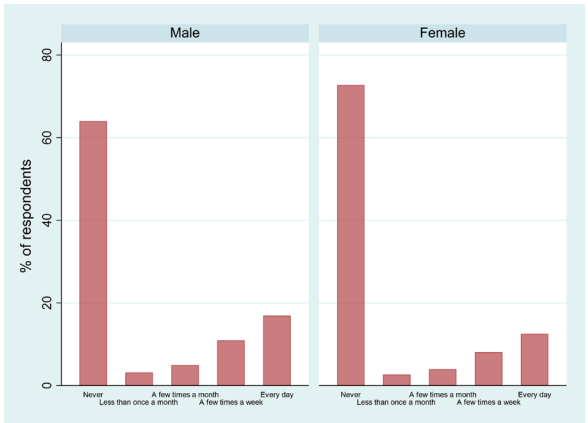
Source: Afrobarometer, 6th round. 0=Never, 1=Less than once a month, 2=A few times a month, 3=A few times a week, 4=Every day. The question on cash income flow was: "Over the past year, how often have you or your family gone without a cash income?"

Figure 4: A multidimensional Internet divide

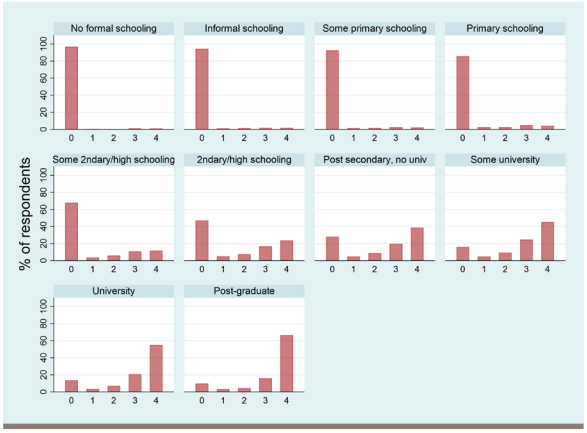
Spatial



Gender



Educational



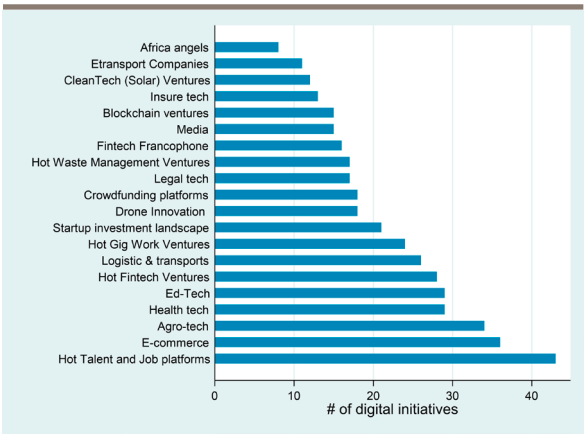
Source: Afrobarometer, 6th round. 0=Never, 1=Less than once a month, 2=A few times a month, 3=A few times a week, 4=Every day. The question on education level was: "What is your highest level of education?".

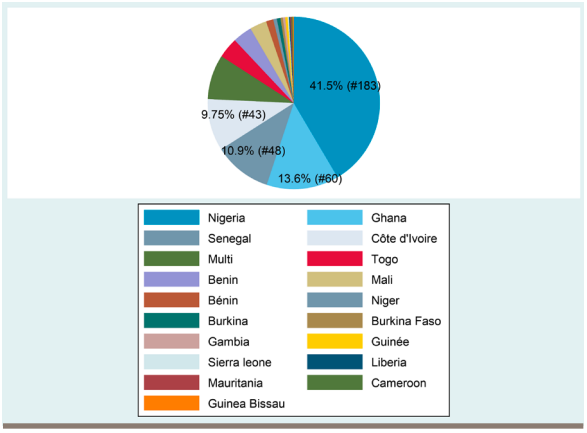
Taking into account the different dimensions that condition the adoption of (mobile) Internet services is necessary to realize the expected dividends of digitization. In particular, an environment more conducive to the adoption internet-related technologies, through enlarged digital infrastructure coverage and reinforced digital skills, could certainly improve the digital dividends for public service delivery, employment, economic diversification, and private sector development in economies of SSA (Ndulu, 2006; Schumann & Kende, 2013). However, interventions promoting digital public service provision through simple mobile phone use should benefit from a better adoption throughout the population, especially in rural areas.

Digital initiatives and public services delivery in Sub-Saharan Africa: what do evidence-based studies tell us?

The uptake of mobile phone technology has facilitated the multiplication of digital innovations throughout the region. In West Africa, this uptake of ICTs has enabled the implementation of more than 400 operational digital initiatives in 2019 (Briter Bridges, 2019) across a wide range of sectors and countries. Fintech, Ed-Tech, Healthtech, Agro-Tech, E-commerce and Job platforms represent the sectors most affected by the expansion of digital initiatives. However, only four countries – Nigeria, Ghana, Senegal and Côte d'Ivoire, in decreasing order – contain more than 75% of these initiatives (Figure 5). Therefore, the digital innovation process is unequally distributed throughout the region, mostly benefitting the four biggest economies of SSA. We review below key evidence-based studies on three major area of public services affected by digital interventions, in West-Africa and the rest of the sub-continent.

Figure 5: Digital innovations multiplication in West Africa



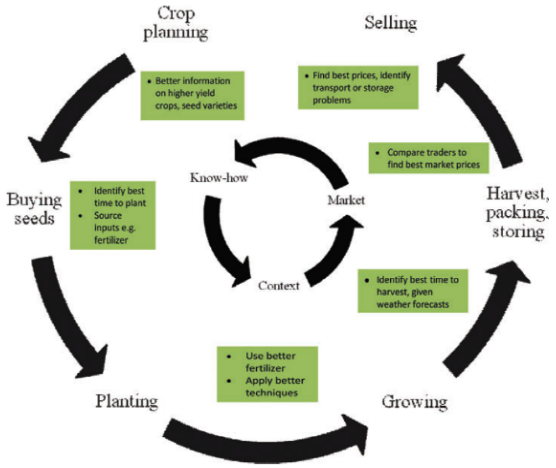


Source: Briter Bridges, innovation maps, 2019. https://briterbridges.com/innovation-maps. Note: 442 digital innovations recorded. Some innovations have been simultaneously implemented in various West African countries. Among them, some are reported under the term "multi." Numbers in this figure are representative, not exhaustive, of the West-African digital economy's expansion.

ICTs and agricultural sector development

The agricultural sector's development and contribution to economic growth in SSA, including West Africa, is hampered by multiple structural constraints. These constraints include harsh climatic conditions, limited infrastructure coverage, rural and sparsely populated regions and markets, low literacy rates among adult populations, and the poor diffusion of agricultural market information and technologies (Aker, 2011; Aker et al, 2016a). Figure 6 below synthesizes how different types of ICTs may respond to informational needs and support agricultural market functioning, from crop planning to sales of produces in agricultural markets.

Figure 6: Information needs along the agricultural production cycle

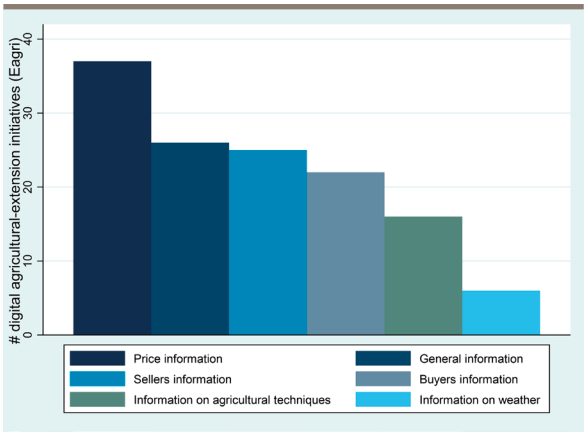


Source: Aker (2011), reproduced from Mittal et al (2010).

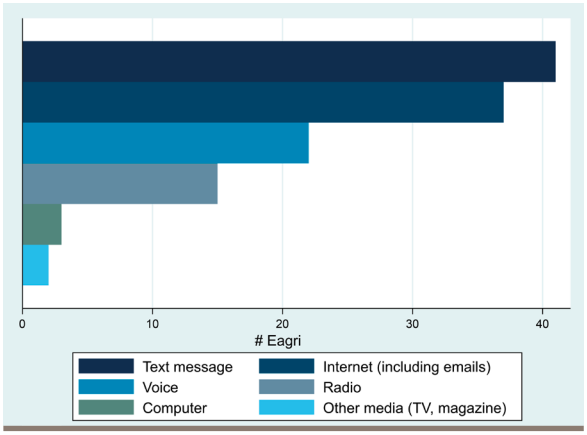
Studies conducted in rural areas of Niger and Ghana confirm that the adoption of communication technologies like mobile phones can increase agricultural market efficiency through multiple mechanisms. For example, digital agricultural extension programs[4] can improve farmers' production and selling decisions, the coordination of input and output supply chains, and farmer bargaining power with traders as well as foster the adoption of efficient or innovative production technologies (Aker, 2011; Aker et al, 2016a). According to GSMA (2019a), there were 81 digital agricultural extension programs (Eagri) currently deployed in SSA (figure 7). Most of these programs provide farmers with information on agricultural prices through text messages or the Internet.

Figure 7: EAGRI deployment in SSA by information and technology type

(A) Information type



(B) Technology type



Source: GSMA Agritech deployment tracker, 2019.

4. Agricultural extension is defined as "the delivery of information inputs to farmers" (Anderson & Feder, 2007). Agricultural extension programs have been put in place to improve farmer access to agricultural market information and learning about agricultural techniques (Aker, 2011).

As pointed out by Aker et al (2016a), to be effective, ICT-based applications for the agricultural sector have to take into consideration various contextual factors. Such factors include the type of informational asymmetry incurred (price risk reduction, increased geographic extent of price information searches, information on agricultural techniques, etc.), the existence of market failures in related markets (e.g. insurance or credit markets), the type of crops cultivated and sold in markets, or the sociodemographic characteristics of farmers.

Moreover, ICTs will empower farmers vis-à-vis other market agents inasmuch they can provide them with trustworthy information (Zanello et al, 2014). In a decentralized private information setting, the reliability of market information depends on the size of the farmer's information network, i.e. the number of information connections from which farmers can extract information (Conley & Udry, 2010). In a centralized public information setting, including those promoted by agricultural extension programs such as a centralized Market Information System, the power of information seems to depend on ICT penetration but also on the degree of adherence to the extension program (Courtois & Subervie, 2014). Ultimately, mobile phone adoption by farmers can serve as a platform for electronic money storage and transfers (mobile money), thereby providing access to insurance and savings mechanisms, which is a critical step towards financial inclusion of unbanked farmers (Aker et al, 2016b).

ICTs and human capital

Educational outcomes

In the context of poor school network coverage in Africa, lacking human and financial resources for education, and missing road and telecommunications infrastructures has given telecommunications technologies – like radio, TV, mobile phones and now smartphones and tablets – an important role in the dissemination of knowledge, the monitoring of educational outcomes and teacher performance (Aker, 2017; Menascé & Clément, 2017).

The implementation of digital technologies in the education sector, when intervention designs use them as monitoring technologies, are found to enhance teacher performance and school administration efficiency (Reinikka & Svensson, 2011; Cilliers et al, 2018). A striking example of successful deployment of school monitoring through digital are the deployment of digital pedagogical platforms, such as the "pret-à-payer" platform in Benin, which are designed to offer teachers, school administrators and parents the possibility to exchange information and to obtain timely access to school financial records through simple mobile technologies (Adida et al, 2018).

Digital technologies have also demonstrated their effectiveness in e-learning adult education programs based on mobile phones, whose basic communication functions (writing messages, making phone calls, making money transfers) can improve learners' numeracy and literacy skills (Aker et al, 2012; Maredia et al, 2018; Aker & Ksoll, 2019). Interestingly, these studies stressed that e-learning technologies are particularly conducive to educational outcomes when they are used as out-of-school learning-by-doing engines, complementary to in-class teaching.

By contrast, researches have stressed the limited or mixed impact of e-learning initiatives for children, based on more sophisticated technologies such as computers or tablets, due to their low uptake in the population and the poor familiarization of intended beneficiaries with them (Banerjee et al, 2007; Linden, 2008; Beuermann et al, 2015). Additional reasons for this include that these technologies are too expensive, more vulnerable to climatic conditions, and more prone to theft. The resulting low uptake in the popu-

lation therefore represents a critical constraint for the scaling up of such initiatives, where they have not proven their relative effectiveness compared to traditional in-class teaching (Linden, 2008).

Health outcomes

The use of ICTs, such as mobile phones or more sophisticated mobile digital technologies, to improve healthcare practices has the potential to change public health intervention design in SSA. In a context of missing health and transport infrastructures, poor health information systems, under-trained health staff, and a predominantly rural and poorly educated population, ICTs – especially mobile phones – can assure various healthcare-related functions.

These technologies can assist with collection and dissemination of information regarding health behaviors, providing healthcare follow-up reminders, or assisting health workers in their everyday work life at relatively low cost (Head et al, 2013; Aranda-Jan et al, 2014; Agarwal et al, 2015; Aker, 2017; Hampshire et al, 2017). Moreover, one particularity of the mobile phone technology is its omnipresence in everyone's life, even the poorest, which make such devices a privileged tool for delivering health information or healthcare services (Head et al, 2013). For these reasons, mobile-based health public services (mHealth), especially those relying on simple mobile phone devices, are expected to promote cost-effective and efficient health policies (Aranda-Jan et al, 2014; Hampshire et al, 2017).

African mobile health (mHealth) projects under study benefitted from a high level of take-up and adherence among patients, health workers and health centers' staff (Agarwal et al, 2015; McNabb et al, 2015; Yé et al, 2018; Laar et al, 2019). Impact assessments have identified the following recurring positive outcomes of these projects: better patient access to basic health services such as medical appointments, reduced delays in communication between patients and health staff, improved data collection and reporting, reduced patient travel costs, better health worker compliance to treatment guidelines, and improved patient sensitization and medication outcomes (Aranda-Jan et al, 2014). Among other things, Aranda-Jan et al (2014) point out that questions of health staff training in use of mobile technology, monitoring and evaluation of technologies, and that setting adequate incentives are central for the success of mHealth project management.

However, a recent study conducted by Hampshire et al (2017) in Ghana and Malawi introduces a more nuanced perspective, in contrast to the solidly optimistic view of many mHealth initiative evaluations. Studying the informal mobile phone practices of health workers in these countries, they highlight the moral and political economy costs incurred by low-level frontline health workers. They found that it was a common practice to informally use mobile phones to deliver extra healthcare services, especially to poor households and hard-to-reach rural communities. Such practices reflect a shift in the workload and tasks borne by low-level health workers, which may in turn reduce health service quality, health worker wellbeing, and the sustainability of mHealth programs.

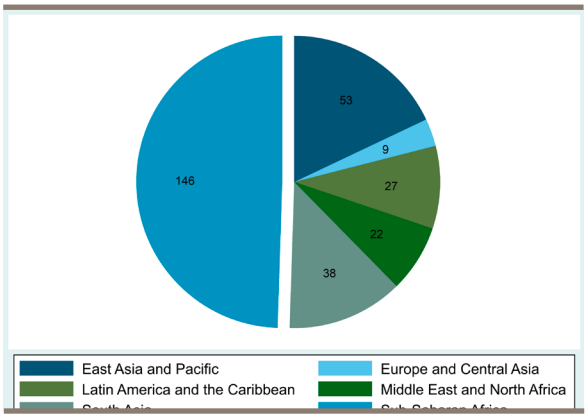
Mobile money and poverty reduction

Mobile Money (MM) is a digital financial service that relies on the mobile phone network to deliver basic financial services – money deposits, money transfers, and withdrawals – without requiring bank account ownership. MM runs on simple mobile phone devices, which explains why its adoption has been rapid and expansive throughout Sub-Saharan Africa. The rapid emergence and diffusion of MM in SSA occurred in a context of high transaction costs and strong market failures in public service provision (Suri, 2017; Aker, 2017; Aron, 2018). The high transpor-

tation and information costs related to missing telecommunications and transportation infrastructures, informational asymmetries on financial markets that exclude the poorest from accessing formal financial services, incomplete insurance markets that preclude households from properly insuring against idiosyncratic and covariant shocks, and the high opportunity costs of holding cash for repeated small transactions and long-term travel, are combined factors that encourage MM diffusion in SSA.

By the end of 2018, 45.6% of registered MM customers was located in SSA, 33.2% was in South Asia and 11% in East Asia and the Pacific. SSA also contains almost half of the MM systems implemented worldwide (Figure 8). The penetration of this technology in the region has reached high levels: while 60% of the adult population has an MM account (almost 100% in Kenya), one-third of the same population was an active user in 13 SSA countries (GSMA, 2018).[5] The pace of MM adoption in SSA has been slowing in recent years (Figure 20). However, there is still significant potential for Nigeria and Ethiopia, the so-called "MM sleeping giants", where financial inclusion and the penetration of MM services is below the regional average (GSMA, 2018).

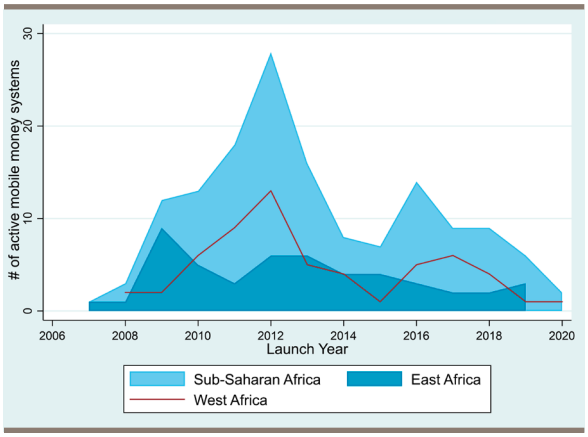
Figure 8: Number of mobile money systems in SSA and the rest of the world



Source: Mobile Money Tracker, GSMA, 2019b. Note: 294 MM systems.

5. Among these 13 countries, 4 were West African countries: Benin, Burkina Faso, Côte d'Ivoire, and Ghana.

Figure 9: Number of mobile money systems in Sub-saharian, West, and East Africa



Source: Mobile Money Tracker, GSMA, 2019b.

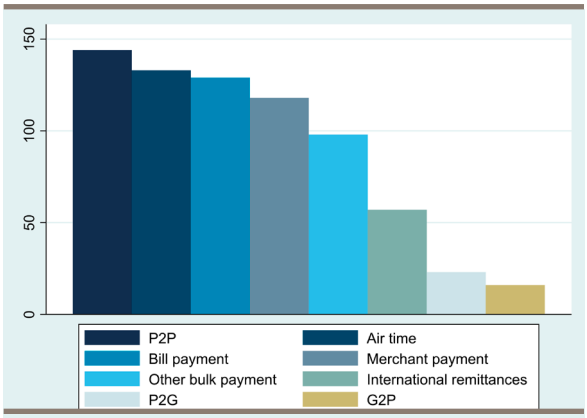
In addition to money storage and person-to-person (P2P) or business-to-business (B2B) payment services, MM systems can also propose person-to-business (P2B) transactions such as sales payments, person-to-government (P2G) transactions such as bills or tax payments, business-to-person (B2P) transactions such as wage payments, or government-to-person (G2P) transactions such as vouchers or cash transfers (Suri, 2017; Aron, 2018). Figure 10 below shows that among the 145 MM systems deployed in SSA, P2P transaction services, airtime, and bill payments are the most common features used across these systems.

MM money could therefore be an effective vehicle for multipurpose financial transactions with a proven effect on financial inclusion. Studies provide strong evidence that MM transfers, through M-Pesa, represented a very effective risk-sharing mechanism in Kenya (Jack & Suri, 2014), but also suggest that such a platform could be effective in other African countries with similar conditions of high transaction costs and financial market failures (Riley, 2018). In fact, MM has been found to improve access to savings or credit (Aker & Wilson, 2013; Bharadwaj et al, 2019), to accelerate poverty alleviation through private remittances (Kikulwe et al, 2014; Munyegera & Matsumoto, 2016), public transfers

such as cash transfers (Aker et al, 2016b), subsidized education fees (Adida et al, 2018), or wage payments (Blumenstock et al, 2015) in various sub-Saharan and other developing countries. Moreover, these benefits are more pronounced for women and female-headed households, which suggests that financial inclusion through mobile money might be particularly effective at fostering women's socioeconomic empowerment (Aker et al, 2016b).

Last, Jack et al (2013) and Jack and Suri (2014) stress that the success of MM depends on the size of the MM agent's network with whom MM users can interact (see also Suri, 2017). Moreover, evidence stresses that user network size is also a critical determinant of MM adoption (Murendo, 2018), supporting that MM is a network good whose social and private benefits increase with the size of other users' networks (Bjorkegren, 2019).

Figure 10: MM System deployment in SSA, by service provided



Source: Mobile Money Tracker, GSMA, 2019b.

Lessons learned and implications for design of future interventions

Digital technologies are network goods whose utility derived by users and socioeconomic impacts depend: (1) on the network size and on the quality of interconnections (Crémer et al, 2000; Bjorkegren, 2019); and (2) on the importance of market failures, transaction costs and infrastructural deficits (Aker, 2017). In this regard, the leapfrogging potential of mobile telephony in Africa has been unparalleled. When the distance between people is immense due to missing road and wireline infrastructures and where market and state failures in the provision of public services are profound, mobile technology is the easiest way for Africans to connect to each other, reduce information asymmetries, and lower transaction costs. As a result, digital initiatives based on mobile phones have multiplied in the region, allowing many Africans to get access to basic public services such as education, health, or financial services.

Digital technologies have proven to be instrumental to address market failures in public service delivery, but their potential for scaling up is potentially hampered by the large and multidimensional digital divide in SSA, characterized by the low penetration of digital technologies in remote areas and among the poorest and most vulnerable segments of African societies. Our analysis stresses that the potential of digital technologies will be fully unleashed if policymakers are able to address persistent obstacles to ICT access that have long remained structural handicaps in African economies: allowing affordable access to energy, extending the landline backbone infrastructure and the mobile Internet network, improving educational attainment, and reducing gender inequalities. As a result, the low penetration of Internet and related technologies in (West) African countries precludes large-scale and more sophisticated usages of digital technologies, particularly usages based on Internet, artificial intelligence, cloud-computing, the Internet of things, or big data. Innovations based on these technologies offer promising perspectives for public service provision and development in Africa, but their bourgeoning nature and limited scale does not

allow rigorous assessment of their impacts as of yet.

The literature review of evidence-based studies proposed in this research analyzes digital technologies' impacts on various areas of public service provision. While this review is not exhaustive, we attempted to cover salient public services that have benefitted from digitization in Sub-Saharan Africa, i.e. agricultural, education, health, and financial services. Therefore, this review does not cover all areas of public services, such as taxation, digital identities, or public utilities management, but instead provides in-depth analyses of key selected digital interventions, highlighting their strengths and weaknesses, emphasizing the main market failures addressed by digital technologies, and identifying the local conditions that permitted or undermined their impact.

Their findings stress that the most basic usages of digital technologies, especially mobile technologies, can yield the greatest benefits for the poor. First, empirical studies show that information dissemination through mobile phone networks significantly reduces informational asymmetries between agricultural markets and farmers, health centers/workers and patients, public school administrations and stakeholders, and money transfer senders and receivers. Therefore, these studies suggest that mobile ownership through affordable telecommunications tariffs, mobile network coverage through investment in the terrestrial infrastructure, and familiarization with mobile usage through adult-training modules are three key ingredients that can unleash the digital dividends of mobile phones, when they are used as an information search engine.

Second, these studies highlight that mobile phones can be a revolutionary payment platform with a proven positive impact on consumption smoothing, risk sharing, access to credit and saving services, and therefore on financial inclusion. Mobile money should also play an increasing role in social protection programs and salary payments (government-to-person transfers), even though this usage is still scarce and has not yet been subject to systematic and rigorous evaluations in Sub-Saharan Africa (Gelb et al, 2020). Moreover, mobile-money system deployments in Kenya and other African countries stress the importance of the size of mobile money infrastructure networks – i.e. mobile money agents and registration points – for this technology to be widespread and successful at promoting financial inclusion. The mobile money infrastructure extension in West Africa is a critical and necessary step towards the massive adoption of mobile money and the generalization of digital identification, necessary for the emergence of mobile banking and digital social protection programs, as can be seen in Kenya (Gelb *et al.*, 2020).

Therefore, to have a significant impact on access to public services and poverty reduction, policymakers should first focus on basic, affordable, user-friendly digital technologies, in particular those based on mobile technologies, and on simple usages such as transmitting market information through phone calls or text messages, or enhancing financial inclusion through mobile money. However, the African connectivity infrastructure network does not yet offer the conditions for effective and efficient delivery of public services through 3G, or 4G technologies. International connectivity is frequently undermined by telecommunications submarine cable outages, provoking recurrent Internet shutdowns in Togo, Benin, Mauritania, Somalia, Cameroon, Mauritius, Comoros, and other countries (Cariolle, 2018; Cariolle et al, 2019). Terrestrial connectivity infrastructures, especially data centers and Internet eXchange Points (IXPs), and energy infrastructures are also particularly missing. On the one hand, most African websites are hosted in foreign data centers, which

has a negative consequence on Internet cost and latency, and on the sovereignty of African networks. On the other hand, poor energy infrastructure coverage and frequent power outages represent another impediment to digital public service uptake.

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