POVERTY

POVERTY AND EQUITY

EQUITABLE GROWTH, FINANCE & INSTITUTIONS INSIGHT

Determinants and Welfare Impacts of Mobile Internet Adoption in African Countries

Carlos Rodríguez-Castelán
Denisse Pierola

WORLD BANK GROUP

MAIN MESSAGES

- *Digital technologies (DTs) are becoming an important mechanism for unleashing inclusive development, particularly across Africa.*
- *The rollout of mobile broadband internet (3G) coverage has expanded substantially in several African countries; however, digital divides persist across various groups.*
- *The issue of affordability—the combination of low household consumption and the high prices of services—is a main constraint on internet adoption across Africa.*
- *Evidence in case studies on Nigeria and Tanzania reveals that greater 3G coverage is associated significantly with higher household consumption, lower poverty rates, and positive labor market outcomes.*
- *Policies focusing on reducing household budget constraints, the price of mobile data, and increasing competition in service provision are critical to supporting the expansion of internet access.*

Acknowledgements:

This note has been prepared by Carlos Rodríguez-Castelán, Lead Economist, EAWPV, and Denisse Pierola, Senior Economist, EFIOS, under the guidance of Carolina Sánchez-Páramo, Global Director, Poverty and Equity Global Practice. Deep gratitude to Rogelio Granguillhome Ochoa for his helpful comments and support in the preparation of this note. This work received funding from the Digital Development Partnership.

>>>

Determinants and Welfare Impacts of Mobile Internet Adoption in African Countries

The digital revolution has swept across the world, shifting behaviors, transforming industries, and unleashing positive impacts on growth. Digital technologies (DTs)— "the internet, mobile phones, and all the other tools to collect, store, analyze, and share information digitally" (World Bank 2016, 2)—are becoming an important mechanism for unleashing inclusive development. Because DTs reduce various costs, including the cost of finding jobs and productive inputs, they enhance productivity, spur jobs, and support innovation and economic growth. In addition to these effects that may be welfare enhancing, DTs also influence household welfare more directly by bringing down prices, expanding choices and information, and improving public service delivery.[1]

Developing countries, including those in Africa, are in the process of harnessing DTs as a source of structural transformation and a pathway to accelerate economic growth. Recent years have seen a swift expansion in coverage and access to the internet in Africa. For instance, the number of unique mobile internet subscribers doubled in the region in the last few years, reaching about 321.1 million in 2021.[2]

However, despite the progress in DT expansion in the region, African countries are still well below world averages in terms of internet use. By 2021, the region's penetration rate—the share of the population using the internet—was 27.2 percent relative to 52.8 percent worldwide. In Sub-Saharan Africa, although only one person in five lives in an area without mobile broadband coverage, the usage gap—the share of the population covered by a mobile broadband network but who do not use it—has been widening year after year, standing at 53 percent in 2020 (Delaporte 2021). This share is larger relative to other regions, such as Europe and Central Asia, East Asia and the Pacific, Latin America, and the Middle East and North Africa, where the usage gaps are 26, 34, 40, and 48 percent, respectively.[3] Expanding the evidence base on DT impacts in Africa is crucial to informing country strategies to reduce poverty and enhance inclusive growth and to reinvigorate the policy dialogue on this front. Policy research on the

1 A growing body of literature has focused on exploring the several benefits of DT access and use. Recent evidence on DTs include the study of impacts on productivity (Abreha et al. 2021), financial inclusion (Aker and Wilson 2013; Ky, Rugemintwari, and Sauviat 2018), price information, access to inputs and consumers (Aker 2011; Aker and Mbiti 2010; Debo and van Ryzin 2013), access to labor (Chun and Tang 2018; De los Rios 2010; Fernandes et al. 2019; Guerrero and Ritter 2014; Hjort and Poulsen 2019; Klonner and Nolen 2010; Marandino and Wunnava 2014; Paunov and Rollo 2015; Viollaz and Winkler 2020), and capital markets (Alibhai et al. 2018; Hasbi and Dubus 2020).

2 The data points in this sentence and the next paragraph are taken from GSMA Intelligence (dashboard), Global System for Mobile Communications (GSM Association), London, accessed May 2022, https://www.gsmaintelligence.com/.

3 Only South Asia had a larger usage gap in 2020, at 61 percent (GSMA 2021).

determinants and welfare impacts of DT adoption across the region has not been extensive. For instance, recent evidence shows that the internet spurs job creation and economic activity in the region (Hjort and Poulsen 2019). However, less is known about the impact of the internet on household and individual welfare. Also, while part of the literature has focused on the effects of cellular services or fixed broadband internet, not much is known about the impact of mobile broadband internet, the primary (and often only) method of digital access among people in the region. Previous work has looked at the effects of DTs on welfare and poverty in developing countries (Beuermann, McKelvey, and Vakis 2012; Blumenstock et al. 2020). Yet, these studies have examined mobile coverage more generally—cellular phones—and have not focused on African countries. In sum, the evidence on the determinants and welfare effects of mobile broadband internet (3G) among African countries is limited.

To fill this gap and to inform evidence-based dialogue on the importance of policy in supporting the expansion and use of DTs in African countries, analytical work conducted in the Poverty and Equality Global Practice, financed by a Digital Development Partnership grant, has investigated both the determinants and the effects of DT adoption, mainly mobile broadband internet (3G), on household welfare in the region. This note brings together the evidence and lessons from five case studies on this subject and presents the analytical framework developed through this project. It also highlights key stylized facts about the state of DT coverage and use in African countries and summarizes findings and policy implications from this body of policy work. The studies are as follows:

- "The Welfare Effects of Mobile Broadband Internet: Evidence from Nigeria" (Bahia et al. 2020)
- "Broadband Internet and Household Welfare in Senegal" (Masaki, Granguillhome Ochoa, and Rodríguez-Castelán 2020)
- "Mobile Internet Adoption in West Africa" (Rodríguez-Castelán, Granguillhome Ochoa, et al. 2021)
- "How Do Digital Technologies Affect Household Welfare in Developing Countries? Evidence from Senegal" (Rodríguez-Castelán, Lach, et al. 2021)
- "Mobile Broadband Internet, Poverty and Labor Outcomes in Tanzania" (Bahia et al. 2021)

How do digital technologies affect household welfare and promote economic growth?

Taking into account the reduction of various economic costs and frictions related to DTs, the analytical framework displayed in figure 1 maps the components of the analysis of DTs impacts (the degree of their availability and take-up) and guides our understanding of the potential channels through which DTs may affect household welfare and promote economic growth.

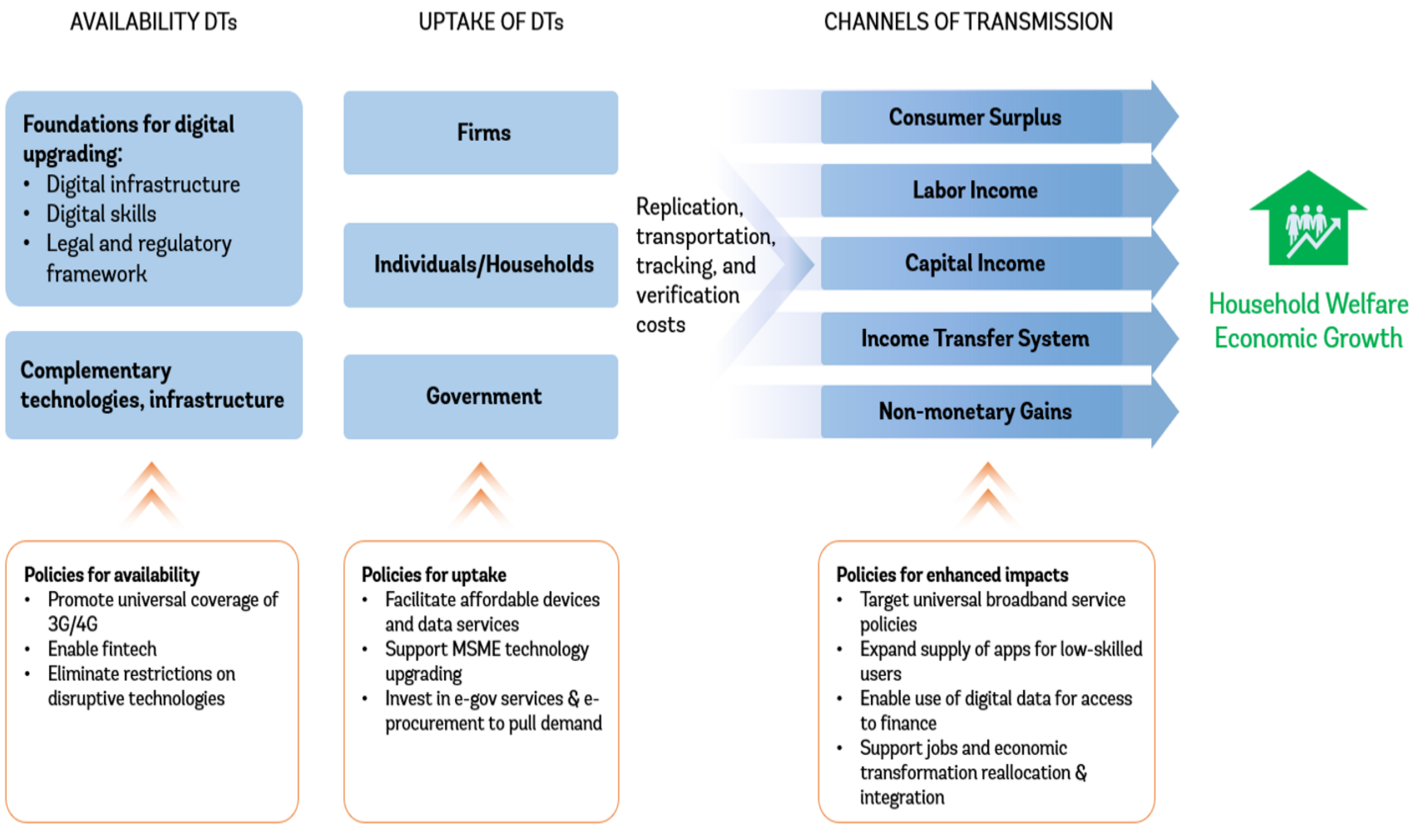
The availability of DTs is determined by the foundations of digital upgrading, such as (1) digital infrastructure, which includes connectivity (such as affordable and available broadband infrastructure), the internet of things (from handsets to access the internet and tractors and irrigation systems with data sensors and applications responsive to the needs of local users, such as farmers), and data repositories; (2) digital skills (digital literacy and DT and business skills); and (3) a legal and regulatory framework that promotes entry and innovation, regulates digital business and finance, and addresses privacy and data-sharing concerns. Complementary analog structures, such as access to electricity and road infrastructure, also play a role in the availability of DTs.

The take-up of DTs by households, firms, and governments is determined by drivers and barriers. These include macro- and microlevel factors on the supply side (such as affordable prices and the local availability of networks, Wi-Fi hotspots, and electricity) and on the demand side (such as purchasing power, access to phones and other digital assets, preferences and skills, and socioeconomic and demographic characteristics, including age or sex).

As DT availability and take-up increase, the analytical framework considers the impact of DTs among firms, individuals, and government across five transmission channels: consumer surplus, labor income, capital income, the tax and transfer system, and

> > >

FIGURE 1 -Analytical Framework, from the Digital Foundations to Household Welfare.



Source: Rodríguez-Castelán, Lach, et al. 2021.

nonmonetary gains. The impacts of DTs ultimately depend on varying intensities in productive use interacted with complementary technologies, infrastructure, access to markets, and potentially less expensive, higher-quality consumer goods and public services.

The framework also highlights potential policies that could be implemented to support digital infrastructure and DT take-up and enhance DT welfare impacts (see the bottom of figure 1). Some of these policy options are discussed in more detail below.

What do we know about the rollout of internet coverage in African countries?

Four of the five revised studies (covering Nigeria, Senegal, and Tanzania) provide an overview of the rollout of 3G coverage and usage in the region.[4] Starting with coverage, map 1 shows the rollout of territorial 3G coverage in Nigeria and Tanzania. In Nigeria, for example, 3G coverage spread from the main cities to a large number of intermediate cities and rural areas in 2010–16, resulting on an increase in population coverage from 21 percent to 57 percent. Relative to fixed broadband internet, which has barely expanded, mobile seems to be the primary platform among users in Nigeria for accessing broadband internet services. In Tanzania, 3G coverage more than doubled between 2008 and 2013, increasing from 16 percent to 35 percent.

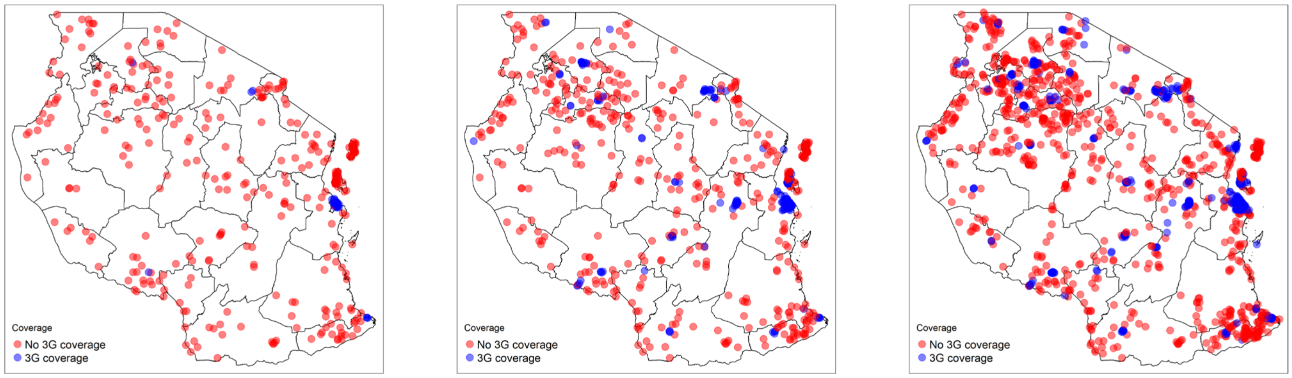
4 Coverage is different from usage or access. Access may occur if an individual has an active SIM card that can be used in a mobile phone to access the internet.

> > >

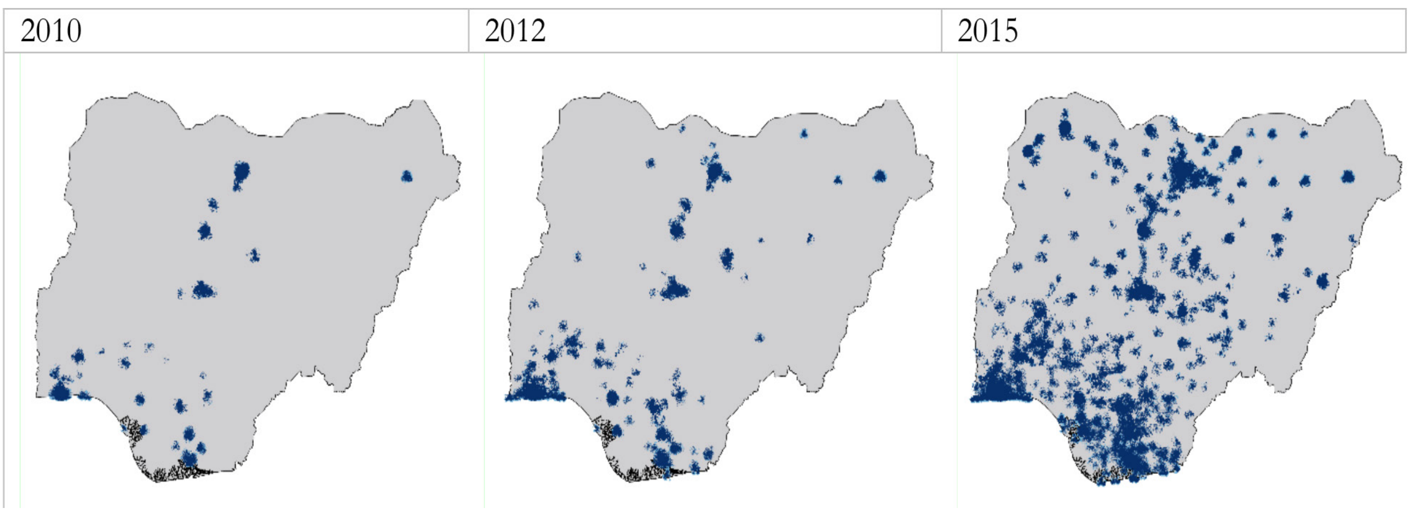
MAP 1 - 3G Coverage, Nigeria and Tanzania

NIGERIA

(a) Wave 1 (2008/9) | (a) Wave 2 (2010/11) | (a) Wave 3 (2012/13)



TANZANIA



Sources: Bahia et al. 2020, 2021; Masaki, Granguillhome Ochoa, and Rodríguez-Castelán 2020.

Regarding access or usage, Sub-Saharan Africa exhibits one of the lowest internet penetration rates among world regions. Based on evidence on countries of the West African Economic and Monetary Union (WAEMU), the penetration rate varies significantly across countries. For instance, in 2019, the share of the population using the internet was 43 percent in Senegal, while it was only 22 percent in Burkina Faso.[5]

This reveals the presence of an important digital divide in coverage and usage that, ultimately, exacerbate inequalities. For instance, a significant 3G coverage gap persisted between urban and rural areas in Senegal in 2019. Similar gaps have been observed between and within cities in Senegal. Connectivity inequality have thus existed between Dakar and secondary cities and also within Dakar.

Additionally, gaps in income, gender, location, age, and education are also evident. Based on information on Senegal in 2018–19, more individuals living in households above the median income threshold were connected to mobile internet (52 percent) relative to individuals living in households below the median (21 percent). Regarding gender, 40 percent of men were connected to mobile

5 See World Development Indicators Databank, World Bank, Washington, DC, https://databank.worldbank.org/source/world-development-indicators.

internet compared with 30 percent of women. There were fewer rural residents than urban dwellers connected to mobile internet (17 percent versus 49 percent, respectively). In terms of age, the rate at which younger individuals (ages 25–40) access the internet through mobile phones was higher (45 percent) relative to the rate observed among older cohorts (21 percent). Finally, 86 percent of individuals with tertiary education or more were connected relative to 20 percent of individuals with less than primary education.

What is curbing the adoption of mobile internet in the region? Evidence from West Africa [6]

Estimates of the likelihood of internet adoption in WAEMU countries reveals that low levels of household consumption and higher prices for services are among the main constraints on mobile broadband adoption (box 1). The finding on the importance of prices is not surprising considering that mobile broadband internet services are expensive in African countries. Burkina Faso, Guinea-Bissau, and Niger are among the countries with the most expensive mobile broadband data-only price baskets in the world, at 19.6 percent of per capita gross national income in Burkina Faso, 22.7 percent in Niger, and 28.8 percent in Guinea-Bissau in 2018 (ITU 2020).

BOX 1: DATA REQUIREMENTS AND METHODOLOGIES TO STUDY THE BARRIERS TO DT ADOPTION

One of the limitations to studying the determinants of DT adoption is that relevant information on DT coverage, access, and use by individuals and households is often not available. However, the study on the barriers to mobile internet adoption across WAEMU countries takes advantage of nationally representative household surveys—the 2018–19 Harmonized Survey of Household Living Conditions—that include information on self-reported access to the internet and use of mobile phones, so that the share of individuals ages 15 or more who use mobile internet can be calculated in all these countries. In addition, these surveys also include information on the main determinants of internet access, such as comprehensive expenditure and consumption aggregates; expenditures on prepaid mobile phone cards, airtime, and data transfers (to calculate a proxy of the price of mobile internet services); demographic profiles (sex, age, language, location); socioeconomic characteristics (education, employment); digital assets ownership (access to television, computers, tablets); and access to complementary infrastructure (for example, electricity).

Because mobile internet adoption depends on internet coverage, mobile coverage data were also needed. In this case, the information was drawn from a digital mapping provider, Collins Bartholomew, complemented, if needed, by data obtained directly from mobile network operators. *

The analysis then consists of the estimation of the probability of adopting the internet based on standard probabilistic models and considering three categories of determinants: (a) drivers of individual demand: income and prices, (b) demographic and socioeconomic characteristics, and (c) complementary infrastructure and policy-related variables. In this analysis, the dependent variable adoption is a binary variable equal to 1 if an individual has access to mobile internet and zero otherwise. This variable is estimated on consumption, a proxy for the local prices of mobile internet services, and a vector of individual-level covariates reflecting all the variables mentioned above.

Because selection bias is a concern (given the dependency of adoption on coverage, which is probably correlated with household income), the analysis should be implemented using a maximum-likelihood two-stage Heckman selection probit model. Under this approach, the analysis assumes there is a fundamental relationship between households in areas covered by 3G (first stage) and households that decide to adopt mobile broadband (second stage). Thus, in a first stage, the probability of benefiting from coverage (selection equation) is estimated using the set of all the determinants mentioned above, plus elevation and road density, which are used as exclusion variables, that is, variables related to mobile coverage, but unrelated to the adoption of mobile internet. Then, in the second stage, the probability of adoption

6 This section is based on Rodríguez-Castelán, Granguillhome Ochoa, et al. (2021).

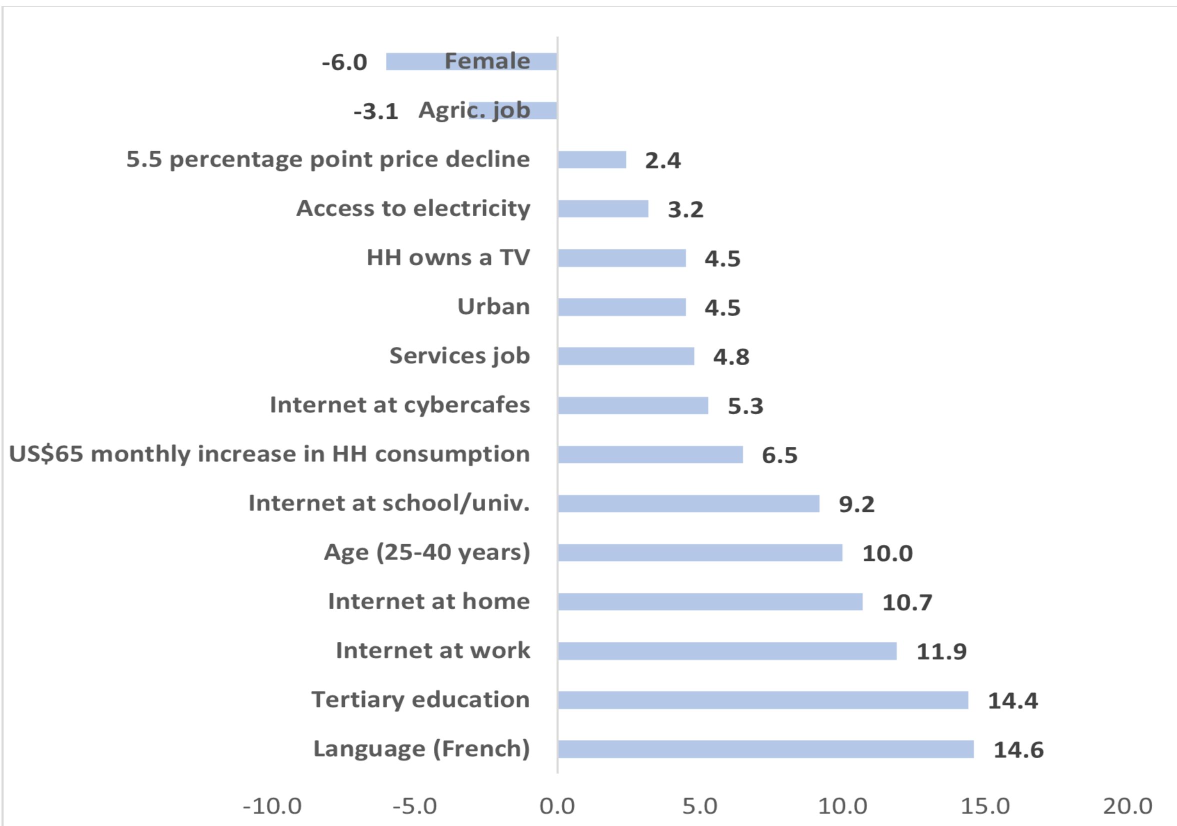
is estimated on the three categories of determinants above, plus the variable retrieved from the first stage, controlling for selection. Linear probability models are also estimated for robustness.

* See Collins Bartholomew (dashboard), HarperCollins Publishers, Glasgow, https://www.collinsbartholomew.com/.

However, high prices are not the only element that matters. Demographic and socioeconomic factors and other determinants related to access to complementary services and alternative means of connection also play an important role as significant barriers to mobile internet adoption. The results from aggregate estimates for all countries—departing from a mean take-up of 20 percent across the region—are summarized in figure 2.

> > >

FIGURE 2 -Variation in the Percentage Point Likelihood of Adoption, WAEMU Countries



Source: Rodríguez-Castelán, Granguillhome Ochoa, et al. 2021.

Note: The figure illustrates average marginal effects from pooled estimations. These are estimates from a regression where the binary dependent variable is mobile internet access, which refers to individuals who access the internet through mobile telephone devices. Because the results are for the pooled sample, country fixed effects are included. Per capita expenditure is a household level variable. Price is obtained by calculating the median expenditure of prepaid mobile phone cards and airtime/data transfers among mobile internet users in each country's geographic area in which the survey is representative. This value is then computed as a share of total consumption in the same geographic level to adjust for the cost of living. This value is imputed to each individual observed in the microdata. The age baseline dummy is 41+ years. The base variable across education categories is individuals with less than primary education. Tertiary is defined as individuals with tertiary education or more. The base category for read/write French refers to national languages, other languages, and those people who cannot read and write. The base variable across labor market sectors refers to inactive and unemployed. The agriculture sector includes jobs in crop yields, fisheries, and animal breeding. Services include commerce, restaurants/hotels, transportation, communication, education, health, other, and personal services jobs. Access to electricity and owning a television are household-level variables. All these results are statistically significant.

The detail of the results from the aggregate estimation, by category of determinants, is as follows:

a. Consumption and prices

The marginal effects from the pooled estimation show that a one standard deviation rise in household consumption, equivalent to about US$65 per capita per month, is linked to an increase in the probability of mobile internet adoption of 6.5 percentage points. A decline in the price of mobile internet of about 5.5 percentage points (as a share of per capita household expenditure)—equivalent to one standard deviation—is related to a rise by 2.4 percentage points in the adoption probability. There is heterogeneity in the results across countries. Appendix A, table A.1 offers a breakdown of the results of estimations by country.

b. Demographic and socioeconomic factors

Demographic and socioeconomic characteristics also correlate with mobile internet adoption. Starting with sex, relative to men, women are 6-percentage points less likely to access the internet. Urban residence increases the likelihood of adoption by 4.5 percentage points. These findings attest to the existence of adoption gaps on both fronts across the WAEMU countries. Regarding age, the results show that younger individuals (ages 25–40) are 10 percentage points more likely to adopt mobile broadband. Language also plays a substantive role. Individuals who can read and write in French (one of the main languages available online) are 14.6 percentage points more likely to access the internet through their mobile phones.

Regarding socioeconomic characteristics, individuals with tertiary education are 14.4 percentage points more likely to adopt mobile broadband than people with less education. Working in agricultural jobs is associated with a decline of 3.1 percentage points in the probability of adoption relative to the unemployed and individuals not actively participating in the labor force. This result is consistent across the WAEMU countries, except Niger. In contrast, those employed in services are 4.8 percentage points more likely to adopt relative to unemployed individuals or those not actively participating in the labor force.

c. Complementary services and policy-related variables

Access to electricity is also linked with an increase in the adoption of mobile internet, by 3.2 percentage points, which underlines the importance of the role of complementary infrastructure in mobile internet adoption. Owning a television is positively associated with mobile broadband internet adoption.

Alternative means of internet access may complement or substitute for mobile broadband adoption. Access to the internet at work showed the closest association with greater adoption, by 11.9 percentage points. Access at home or in school or university is associated with a rise in the probability of adoption by 10.7 and 9.2 percentage points, respectively. Access in cybercafes shows mixed results in adoption.

What are the impacts of adoption on welfare? Evidence from Nigeria and Tanzania[7]

Evidence from case studies on Nigeria and Tanzania reveal that the association is significant between mobile broadband internet (3G) coverage and higher household consumption and lower poverty rates (box 2). For instance, in Nigeria, the results show that 3G coverage increases total, food, and nonfood consumption by 5.8 percent, 6.2 percent, and 6.3 percent, respectively, which is linked to a reduction of 4.3 percentage points in extreme poverty.[8] All these effects in Nigeria are significant after at least one year of 3G coverage. Similarly, in Tanzania, total consumption increased by 7 percent–11 percent after one year of 3G coverage. Food consumption and nonfood consumption also increased, by 7 percent–10 percent and 9 percent–11 percent, respectively. The basic needs poverty rate also declined, by 4 to 7 percentage points.[9] These effects are also significant after one year of 3G coverage. (See appendix A, table A.2 for a summary of the significance of the effects across studies.)

---

7 Three of the five papers revised for this note evaluate the impacts of mobile broadband internet on welfare: the papers on Nigeria, Senegal, and Tanzania. However, for a more appropriate comparison, the section focuses on the results obtained from the case studies conducted in Nigeria and Tanzania because these studies are based on similar (longitudinal) data and a similar empirical approach. However, all the results described in this section are also consistent with the results of the case study in Senegal (Masaki, Granguillhome Ochoa, and Rodríguez-Castelán 2020), despite the fact that this study is based on a different type of data (repeated cross sections).

8 The extreme poverty status of households is calculated based on the international poverty line of US$1.90 per day (2011 US dollars at purchasing power parity).

9 The basic needs poverty line measures the cost of acquiring sufficient food to provide adequate daily nutrition per person (food line), plus the cost of some nonfood essentials (the nonfood component).

BOX 2: WHAT ARE THE DATA REQUIREMENTS AND METHODOLOGIES OF THE ANALYSIS OF DT WELFARE IMPACTS?

The welfare impacts of mobile broadband (3G) internet can be analyzed by integrating household data—ideally longitudinal data that follow the same households and individuals over time to capture welfare outcomes—with mobile broadband internet coverage maps. Coverage is used instead of usage for two reasons: (a) coverage is external to household decisions and (b) 3G coverage captures the direct impact of households accessing 3G, along with spillover effects, such as internet users sharing information with nonusers.

For this analysis, the variables used are measures of consumption (total, food, and nonfood) and whether such consumption is sufficient to classify a household as above or below various poverty lines (US$1.90, US$3.20, and the basic needs of the poor). In addition, for labor market outcomes, the main variables of interest are wages, earnings, (formal) employment, and sectoral employment (farm versus nonfarm).

On 3G coverage, the studies used geospatial information on rollout coverage. The network infrastructure information can be sourced from available public databases, such as the mobile coverage maps database in the Senegal study, or collected directly from mobile network operators, as was also the case in the Nigeria and Tanzania studies. Then, because coverage maps are calculated using different models (such as the radio propagation model or the irregular terrain model), the location of households in the survey—established using GPS coordinates of the centroid of the enumeration areas—is matched with the coverage footprint for each radio bearer. Coverage per household is determined based on whether the household is covered by different signal strengths, normally medium or strong.

The impact estimation uses a difference-in-differences approach that compares outcomes among households in treated areas (with 3G network coverage) and nontreated areas before and after the mobile broadband internet expansion. In this estimation, the treatment is normally a variable equal to 1 if the household or individual is covered by a 3G network at a given time and zero otherwise. If possible (as in Nigeria and Tanzania), the treatment effect is estimated accounting for differences in the amount of time of the exposure to coverage (one year, two years, or three years). Time-variant variables—covering household and enumeration area characteristics—and access to other networks (2G) are added as controls. If the household data are longitudinal, as in the case in the Nigeria and Tanzania studies, household or individual effects are added. If such data are not available and the analysis relies on repeated cross-section data, region fixed effects are used instead, as in the Senegal study. Time fixed effects are always included.

Given that there may be omitted variables that confound the relationship between welfare and the 3G coverage, endogeneity concerns are addressed in different ways. In Nigeria, pretreatment trends are tested, and additional specifications exploiting a quasi-random treatment (accounting for households that were not intended to obtain 3G coverage) are analyzed. In Senegal, two-stage least squares regression analysis, instrumenting with the distance to 3G coverage in neighboring areas outside the immediate vicinity of a given enumeration area, is employed as a robustness check. In Tanzania, nonlinear time trends for each region and nonlinear time trends based on the observed characteristics of the household location were added.

The effects are heterogeneous across different groups within a given country. Appendix A, table A.3, panel a, shows how results vary across households or individuals with different attributes by sex, location, age, and education of individuals or household heads. In terms of sex, the evidence is mixed. For instance, in Nigeria, only man-headed households observed positive and significant impacts on total consumption and poverty reduction. However, in Tanzania, the evidence on positive effects on consumption is more robust among woman-headed households, and the result for man-headed households is barely statistically significant. A decline in basic needs poverty is observed among both man- and woman-headed households.

Another important digital divide is between rural and urban areas. The results in Tanzania show more significant positive effects on total consumption and on poverty reduction among urban households. In Nigeria, the positive effects on consumption and poverty reduction are more significantly concentrated among rural households exposed to 3G for one year or more. The difference in the results may reflect the fact that the data in Tanzania capture early rollout stages (from zero to nonzero coverage in the early 2010s) relative to Nigeria's later rollout stages (from 30 percent to 70 percent coverage in mid- to late 2010s). Thus, the results indicate that, at early rollout stages, urban areas seem to benefit more (Tanzania), while rural areas do so at later rollout stages as coverage expands further (Nigeria).

In terms of education, the evidence is also mixed. In the case of Nigeria, there is evidence of technical skill–bias change, with larger improvements among households headed by individuals with more education. These households observed reduced poverty after one year of 3G coverage. However, all households experienced gains in terms of total consumption regardless of the head's years of education. Meanwhile, in Tanzania, positive gains in total consumption and poverty reduction gains are concentrated in households headed by less well-educated people.

The digital divide by age seems to favor younger people. In both countries, statistically significant gains in poverty reduction are more highly concentrated among households headed by younger people. However, significant gains in total consumption are observed among both younger and older groups in both countries.

The studies also include analysis of the effects on labor market outcomes because this is one of the main channels through which DTs translate into improvements in welfare. Overall, 3G coverage has positive effects on labor force participation, wage employment, formal employment, and nonfarm employment across countries (see appendix A, table A.3, panel b). The results by country reveal differences in statistical significance. In Nigeria, 3G coverage explains a 2.6 percentage point increase in labor force participation after three years of coverage and a 1.4 percentage point increase in wage employment after three or more years of coverage. The effect on labor participation is significant among women and younger people (ages under 30) after two years or more of coverage. The effect of 3G coverage also yields positive dividends in labor force participation among those individuals who are well-educated, living in initially poorer households, or in rural areas. Similar results are observed for wage employment.

In the case of Tanzania, individuals living in 3G-covered areas increased their labor participation and their wage and nonfarm self-employment by 3 to 8 percentage points after one to two years of exposure. 3G coverage reduced farm employment by 4 to 9 percentage points. Positive gains in labor force participation and wage employment are significant among men, younger well-educated individuals and individuals living in urban areas.

Other impacts: expanding financial inclusion.

Another channel through which DTs improve livelihoods is by expanding financial inclusion with the use of instruments such as mobile money. This may boost the affordability and availability of financial services among underserved populations because it fosters interconnectivity among banks, reduces the costs of financial transactions, and expands the supply represented by mobile money agents to rural areas. Indeed, the experience in Kenya shows that access to the mobile money system M-PESA increased per capita consumption and lifted 2 percent of Kenyan households out of poverty (Suri and Jack 2016).

Evidence from Senegal shows that complementary policies aimed at expanding mobile internet coverage and raising access to mobile money accounts would reduce gaps across subgroups because they would increase the take-up of these services among women and individuals in the bottom 40 percent of the income distribution. Based on a simulation exercise in Senegal, doubling the 2020 share of mobile money users from 31.8 percent to 63.6 percent would raise account ownership among women from 29 percent to 57 percent, induce growth in account access among rural residents from 27 percent to 62 percent, and reduce the mobile money gap between the top and bottom quintiles by 5.1 percentage points (Cruz, Dutz, and Rodríguez-Castelán 2021). Improved access, in turn, may eventually increase the use of mobile accounts to send and receive payments and private transfers. Indeed, the simulation results predict a rise in the share of remittances by 70 percent and a doubling in private payments related to labor, such as wages and payments for self-employment and agricultural activities. In the long run, greater access to digital financial services may have a positive and significant impact on welfare.

Policy discussion

The findings in these studies improve our understanding of an array of factors that restrain mobile internet usage in African countries and the impact of 3G coverage on welfare. They also contribute to and are aligned with the general literature diagnosing the drivers and welfare effects of mobile internet (box 3). Although the focus is on consumption and poverty, the evidence also highlights welfare gains through labor markets and financial inclusion. Because some of these findings include insights on barriers and gains across different groups, they also provide an opportunity to examine at policies that prioritize internet access and connectivity for all and that also allow the targeting of specific population groups and geographic areas that may have been left out and are not yet reaping the gains of DTs.

BOX 3: EVIDENCE FROM OTHER REGIONS OF THE WORLD

The findings in West Africa are aligned with evidence from other parts of the world that assesses the key drivers of internet adoption. The empirical literature identifies age, education, location, income, household size, and skills as factors related to the adoption and use of DTs. Martínez-Domínguez and Mora-Rivera (2020) find that rural internet users in Mexico tend to be well-educated, digitally educated, young, and wealthier. Similar to the framework employed in the West Africa analysis described above, Grazzi and Vergara (2014) also find that education levels, wealth, household size, location, presence of students in the household, and network effects induce internet adoption across seven Latin American countries. In Indonesia, Puspitasari and Ishii (2016) suggest that the ownership of feature phones, which are able to access the internet, but with less functionality than smartphones, is concentrated among less well-educated individuals and older people regardless of income. They also find that internet adoption through these phones is greater among younger and more highly educated individuals.

The results of this work are also closely aligned with the broader literature assessing the effects of the mobile internet on welfare in terms of consumption and poverty, labor market outcomes, and functioning rural markets. In Peru, Beuermann, McKelvey, and Vakis (2012) find that mobile phone expansion increased household consumption by 11 percent and reduced poverty and extreme poverty by 8 and 5.4 percentage points, respectively. These results are similar in magnitude to those of Bahia et al. (2021) in Nigeria. In terms of labor market outcomes, Viollaz and Winkler (2020) show that, in Jordan, access to mobile broadband increases labor force participation among women, inducing a reduction in gender-biased social norms, marriage, and fertility. In rural Vietnam, Kaila and Tarp (2019) find that internet access is associated with higher agricultural output and productivity gains driven by a more efficient use of fertilizers.

Expanding and improving the availability of affordable digital infrastructure are important. In the case of Africa, this requires expanding competition in the information and communication technology industry across countries.[10] Increasing competition in digital infrastructure has measurable impacts on welfare. It may lead to lower prices and thereby raise the purchasing power of current consumers and allow new users who were previously priced out to adopt information and communication technology services.[11]

The results on the determinants of mobile broadband internet adoption underline how policies supporting consumption and price reductions are also vital to raising the usage of DTs. These policies may include those that reduce household budget constraints, such as direct social assistance transfers and the removal of barriers to financial inclusion and job creation, as well as other policies that aim to reduce mobile data prices, such as reforms to increase competition in service provision through an increase in the number of competitors or a reduction in the market power of broadband monopolies.

---

10 As of 2021, 34 countries in the region had a dominant wireless operator with a market share of more than 50 percent (as measured by total mobile connections). Of these countries, two had a monopoly, and another six had an operator that accounted for more than 70 percent of the market share. See GSMA Intelligence (dashboard), Global System for Mobile Communications (GSM Association), London, accessed May 2022, https://www.gsmaintelligence.com/.

11 A simulation exercise in Senegal using the World Bank's WELCOM tool shows that the greater competition resulting from an increase in the number of information and communication technology operations from three to six would generate a 2.9 percentage point rise in the number of users because of the lower estimated price of services. This analysis also estimates a combined welfare effect of competition on both current and new users that would induce a total poverty reduction of 0.72 percentage points in the medium term. Also applying the WELCOM tool, Rodríguez-Castelán, Araar, et al. (2021) find that diluting Ethiopia's state-owned telecommunication monopoly would result in a price reduction in mobile services of 25.3 percent, leading to an expansion by 4.6 million new users. These results translate into a welfare gain of 1.37 percent among all consumers, equivalent to a reduction in the national poverty rate of 0.31 percentage points. See WELCOM Stata Tool, Global Solutions Group on Markets and Institutions for Poverty Reduction and Shared Prosperity, Poverty and Equity Global Practice, World Bank, Washington, DC, http://dasp.ecn.ulaval.ca/webwel/welcom.html.

Regulatory frameworks that (1) foster interconnectivity among banks, reduce transaction costs, and grow the supply of mobile money agents in rural areas and (2) promote innovation and regulate a country's approach to digital business models, privacy, and data sharing are desirable in supporting financial inclusion and competitive digital markets. They can be fundamental to shaping the inclusiveness of digital-driven growth.

Additionally, policies targeting internet use among underserved groups could mitigate the inequality-exacerbating impact of digital divides, as follows:

- *Sex*. The fact that women in West Africa are less likely than men to access the internet through mobile devices points to the need for gender-specific approaches to promote the adoption of DTs. These policies may include the provision of digital literacy training and initiatives to promote sustainable mobile device and service financing schemes targeted particularly at women.

- *Education, literacy, and digital skills*. Mobile internet adoption is more prevalent among well-educated individuals. This is important given the existing educational gaps in the region. Higher literacy in general and digital literacy in particular represent an important foundation to help reduce digital gaps. Also, given that internet access at school or university is also associated with an increase in the likelihood of mobile broadband adoption, investing in digital capacity and infrastructure in these sectors could also help close gaps.

- *Sector and location gaps*. The fact that individuals in agricultural jobs are less likely to adopt mobile broadband internet should encourage research into ways to support digitalization and access to the internet in the agricultural sector and in rural areas where these jobs are more prevalent. In this sense, policies geared toward the universal coverage of 3G mobile services are key to mitigating the risk of a widening digital divide, particularly between urban and rural areas.

>>>

References

Abreha, Kaleb Girma, Jieun Choi, Woubet Kassa, Hyun Ju Kim, and Maurice Kugler. 2021. "Mobile Access Expansion and Price Information Diffusion: Firm Performance after Ethiopia's Transition to 3G in 2008." Policy Research Working 9752, World Bank, Washington, DC.

Aker, Jenny C. 2011. "Dial 'A' for Agriculture: A Review of Information and Communication Technologies for Agricultural Extension in Developing Countries." *Agricultural Economics* 42 (6): 631–47.

Aker, Jenny C., and Isaac M. Mbiti. 2010. "Mobile Phones and Economic Development in Africa." *Journal of Economic Perspectives* 24 (3): 207–32.

Aker, Jenny C., and Kimberley Wilson. 2013. "Can Mobile Money Be Used to Promote Savings? Evidence from Northern Ghana." SWIFT Institute, Working Paper 2012-003, SWIFT Institute, London.

Alibhai, Salman, Niklas Buehren, Rachel Coleman, Markus P. Goldstein, and Francesco Strobbe. 2018. "Disruptive Finance: Using Psychometrics to Overcome Collateral Constraints in Ethiopia." February, World Bank. Washington, DC.

Bahia, Kalvin, Pau Castells, Takaaki Masaki, Genaro Cruz, Carlos Rodríguez-Castelán, and Viviane Sanfelice. 2021. "Mobile Broadband Internet, Poverty and Labor Outcomes in Tanzania." Policy Research Working Paper 9749, World Bank, Washington, DC.

Bahia, Kalvin, Pau Castells, Genaro Cruz, Takaaki Masaki, Xavier Pedrós, Tobias Pfutze, Carlos Rodríguez-Castelán, and Hernán Jorge Winkler. 2020. "The Welfare Effects of Mobile Broadband Internet: Evidence from Nigeria." Policy Research Working Paper 9230, World Bank, Washington, DC.

Beuermann, Diether W., Christopher McKelvey, and Renos Vakis. 2012. "Mobile Phones and Economic Development in Rural Peru." *Journal of Development Studies* 48 (11): 1617–28.

Blumenstock, Joshua Evan, Niall Carrigan Keleher, Arman Rezaee, and Erin Troland. 2020. "The Impact of Mobile Phones: Experimental Evidence from the Random Assignment of New Cell Towers." Background paper, Innovations for Poverty Action, New Haven, CT.

Chun, Natalie, and Heiwai Tang. 2018. Do Information and Communication Technologies Empower Female Workers? Firm-Level Evidence from Viet Nam, ADB Economics Working Paper 545 (May), Asian Development Bank, Manila.

Cruz, Marcio, Mark A. Dutz, and Carlos Rodríguez-Castelán. 2021. *Digital Senegal for Inclusive Growth: Technological Transformation for Better and More Jobs*. International Development in Focus Series. Washington, DC: World Bank.

Debo, Laurens G., and Garrett John van Ryzin. 2013. "Leveraging Quality Information in Stock-Outs." Research Paper 13–58, University of Chicago Booth School of Business, Chicago.

Delaporte, Anne. 2021. "The State of Mobile Internet Connectivity in Sub-Saharan Africa: Why Addressing the Barriers to Mobile Internet Use Matters Now More Than Ever." *Connected Society* (blog), October 27, 2021. https://www.gsma.com/mobilefordevelopment/blog/the-state-of-mobile-internet-connectivity-in-sub-saharan-africa/.

De los Rios, Carlos. 2010. "Welfare Impact of Internet Use on Peruvian Households." Instituto de Estudios Peruanos, Lima, Peru.

Fernandes, Ana Margarida, Aaditya Mattoo, Huy Le Nguyen, and Marc Tobias Schiffbauer. 2019. "The Internet and Chinese Exports in the Pre-Ali Baba Era." *Journal of Development Economics* 138 (May): 57–76.

Grazzi, Matteo, and Sebastián Vergara. 2014. "Internet in Latin America: Who Uses It? . . . and for What?" *Economics of Innovation and New Technology* 23 (4): 327–52.

GSMA (GSM Association). 2021. "Connected Society: The State of Mobile Internet Connectivity 2021." September, GSMA, London. https://www.gsma.com/r/wp-content/uploads/2021/09/The-State-of-Mobile-Internet-Connectivity-Report-2021.pdf.

Guerrero, María Eugenia, and Patricia I. Ritter. 2014. "The Effect of Internet and Cell Phones on Employment and Agricultural Production in Rural Villages in Peru." Tesis de pregrado en Economía, Programa Académico de Economía y Finanzas, Facultad de Ciencias Económicas y Empresariales, Universidad de Piura, Piura, Peru.

Hasbi, Maude, and Antoine Dubus. 2020. "Determinants of Mobile Broadband Use in Developing Economies: Evidence from Sub-Saharan Africa." *Telecommunications Policy* 44 (5), 101944.

Hjort, Jonas, and Jonas Poulsen. 2019. "The Arrival of Fast Internet and Employment in Africa." *American Economic Review* 109 (3): 1032–79.

ITU (International Telecommunication Union). 2020. *Measuring Digital Development: ICT Price Trends 2019*. Geneva: ITU.

Kaila, Heidi, and Finn Tarp. 2019. "Can the Internet Improve Agricultural Production? Evidence from Viet Nam." *Agricultural Economics 50* (6): 675–91.

Klonner, Stefan, and Patrick James Nolen. 2010. "Does ICT Benefit the Poor? Evidence from South Africa." Paper presented at the German Development Economics Conference, Hanover, Germany, June 18–19, 2010.

Ky, Serge, Clovis Rugemintwari, and Alain Sauviat. 2018. "Does Mobile Money Affect Saving Behaviour? Evidence from a Developing Country." *Journal of African Economies* 27 (3): 285–320.

Marandino, Joaquin, and Phanindra V. Wunnava. 2014. "The Effect of Access to Information and Communication Technology on Household Labor Income: Evidence from One Laptop per Child in Uruguay." IZA Discussion Paper 8415 (August), Institute of Labor Economics, Bonn, Germany.

Martínez-Domínguez, Marlen, and Jorge Mora-Rivera. 2020. "Internet Adoption and Usage Patterns in Rural Mexico." *Technology in Society* 60 (February), 101226.

Masaki, Takaaki, Rogelio Granguillhome Ochoa, and Carlos Rodríguez-Castelán. 2020. "Broadband Internet and Household Welfare in Senegal." Policy Research Working Paper 9386, World Bank, Washington, DC.

Paunov, Caroline, and Valentina Rollo. 2015. "Overcoming Obstacles: The Internet's Contribution to Firm Development." *World Bank Economic Review* 29 (Supplement 1): S192–S204.

Puspitasari, Lia, and Kenichi Ishii. 2016. "Digital Divides and Mobile Broadband in Indonesia: Impact of Smartphones." *Telematics and Informatics* 33 (2): 272–83.

Rodríguez-Castelán, Carlos, Abdelkrim Araar, Eduardo A. Malásquez, and Rogelio Granguillhome Ochoa. 2021. "Competition Reform and Household Welfare: A Microsimulation Analysis of the Telecommunication Sector in Ethiopia." Policy Research Working Paper 9516, World Bank, Washington, DC.

Rodríguez-Castelán, Carlos, Rogelio Granguillhome Ochoa, Samantha Lach, and Takaaki Masaki. 2021. "Mobile Internet Adoption in West Africa." Policy Research Working Paper 9560, World Bank, Washington, DC.

Rodríguez-Castelán, Carlos, Samantha Lach, Takaaki Masaki, and Rogelio Granguillhome Ochoa. 2021. "How Do Digital Technologies Affect Household Welfare in Developing Countries? Evidence from Senegal." Policy Research Working Paper 9576, World Bank, Washington, DC.

Suri, Tavneet, and William Jack. 2016. "The Long-Run Poverty and Gender Impacts of Mobile Money." Science 354 (6317): 1288–92.

Viollaz, Mariana, and Hernán Jorge Winkler. 2020. "Does the Internet Reduce Gender Gaps? The Case of Jordan." Policy Research Working Paper 9183, World Bank, Washington, DC.

World Bank. 2016. World Development Report 2016: *Digital Dividends*. Washington, DC: World Bank.

>>>

Appendix A: Tables

> > >

TABLE A.1 - Average Marginal Effects of Variation in Household Consumption and Prices

COUNTRY	INCREASE IN ADOPTION LIKELIHOOD (IN PP), IF: ONE S.D. INCREASE IN HH CONSUMPTION	ONE S.D. DECLINE IN PRICES
Benin	4.8***	1.4***
Côte d'Ivoire	7.3***	2.1***
Guinea-Bissau	5.0***	3.4***
Mali	5.1***	2.3***
Niger	3.5***	1.0***
Senegal	9.0***	3.2***
Togo	6.2***	1.5***

Source: Rodríguez-Castelán, Granguillhome Ochoa, et al. 2021.
Note: Average marginal effects from separate regressions by country. The binary dependent variable in each regression is mobile internet access, which refers to individuals who access the internet through their mobile telephone devices. Per capita expenditure is a household level variable. HH - household. S.D. = standard deviation.
*Significance: * p < .1 ** p < .05 *** p < .01*

> > >

TABLE A.2 - Baseline Results on the Impacts of Mobile Broadband Internet

	NIGERIA	TANZANIA
HOUSEHOLD-LEVEL		
Total consumption	(+), ** (after 1y coverage)	(+), ***
Food consumption	(+), ** (after 1y coverage)	(+), **
Non-food consumption	(+), ** (after 1y coverage)	(+), ***
Basic Need Poor		(+), ***
Extreme poor ($1.9 PPP)	(-), *** (after 1y coverage)	(-), n-s
Moderate poor ($3.2 PPP)	(-), n-s	(-), n-s
INDIVIDUAL-LEVEL		
Labor participation	(+), ** (after 2y coverage)	(+), **
Wage employment	(+), * (after 3y coverage)	(+), **
Self-employment Non-Farm	(+), n-s	(+), **
Self-employment Farm	(+) and (-), n-s	(-), ***

Sources: Bahia et al. 2020, 2021; Masaki, Granguillhome Ochoa, and Rodríguez-Castelán 2020.
Note: (+), (-) = the sign of the coefficient in baseline estimations. n-s = nonsignificant.
*Significance: * p < .1 ** p < .05 *** p < .01*

> > >

TABLE A.3 - Heterogeneous Effects of Mobile Broadband Internet

a. Consuption and Poverty

	TOTAL CONSUMPTION:		BASIC NEED POOR	POVERTY ($1.9)	
	NIGERIA	TANZANIA	TANZANIA	NIGERIA	TANZANIA
Male head	(+), *** (after 1y coverage)	(+), *	(-), **	(-), *** (after 1y coverage)	(-), n-s
Female head	(+), n-s	(+), ***	(-), **	(-), n-s	(-), ***
Urban	(-), * (after 3y coverage)	(+), ***	(-), ***	(-), * (after 2y coverage)	(-), n-s
Rural	(+), ** (after 1y coverage)	(+), n-s	(-), *	(-), ** (after 1y coverage)	(-), n-s
Low-consumption	(+), *** (after 1y coverage)	(+), ***	(-), ***	(-), *** (after 1y coverage)	(-), ***
High consumption	(+), * (after 1y coverage)	(+), n-s	(-), n-s	(-), ** (after 1y coverage)	(+), ***
Less-educated head (less than primary educ.)	(+), ** (after 2y coverage)	(+), ***	(-), ***	(-), n-s	(-), *
Educated head (primary educ. or more)	(+), *** (after 1y coverage)	(+), n-s	(-), n-s	(-), *** (after 1y coverage)	(-), n-s
Younger (below 50y Nigeria and Senegal, below 30y Tanzania)	(+), * (after 1y coverage)	(+), **	(-), ***	(-), *** (after 1y coverage)	(-), *
Older (above 50y Nigeria and Senegal, above 30y Tanzania)	(+), ** (after 1y coverage)	(+), **	(-), *	(-), n-s	(-), n-s

b. Labor Outcomes

	LABOR FORCE PARTICIPATION		WAGE EMPLOYMENT	
	NIGERIA	TANZANIA	NIGERIA	TANZANIA
Male head	(+), * (after 2y coverage)	(+), ***	(+) and (-), n-s	(+), ***
Female head	(+), ** (after 2y coverage)	(+), n-s	(+), *** (after 3y coverage)	(+), n-s
Urban	(+) and (-), n-s	(+), ***	(+), * (after 3y coverage)	(+), **
Rural	(+), * (after 2y coverage)	(-), n-s	(+), n-s	(-), n-s
Low-consumption	(+), ** (after 2y coverage)	(+), n-s	(+), * (after 3y coverage)	(+), n-s
High consumption	(+), ** (after 3y coverage)	(+), **	(+) and (-), n-s	(+), ***
Less-educated head (less than primary educ.)	(+) and (-), n-s	(-), n-s	(+) and (-), n-s	(+), **
Educated head (primary educ. or more)	(+), * (after 3y coverage)	(+), ***	(+), ** (after 3y coverage)	(+), *
Younger (below 50y Nigeria and Senegal, below 30y Tanzania)	(+), ** (after 2y coverage)	(+), ***	(+), * (after 2y coverage)	(+), ***
Older (above 50y Nigeria and Senegal, above 30y Tanzania)	(+), n-s	(+), n-s	(-), n-s	(-), n-s

Sources: Bahia et al. 2020, 2021; Masaki, Granguillhome Ochoa, and Rodríguez-Castelán 2020.
Note: (+), (-) = the sign of the coefficient in baseline estimations. n-s = nonsignificant.
*Significance: * p < .1 ** p < .05 *** p < .01*

WORLD BANK GROUP