

POLICY RESEARCH WORKING PAPER

9560

WORLD DEVELOPMENT REPORT 2021

Background Paper

Mobile Internet Adoption in West Africa

Carlos Rodríguez-Castelán
Rogelio Granguillhome Ochoa
Samantha Lach
Takaaki Masaki



WORLD BANK GROUP

Poverty and Equity Global Practice

March 2021

Abstract

Mobile broadband internet is the main technology through which individuals access the internet in developing countries. Understanding the barriers to broadband adoption is thus a priority in designing policies aiming to expand access and close the digital divide across socioeconomic groups and territories. This paper exploits data from harmonized household expenditure surveys in seven countries in West Africa in 2018/19—a subregion with one of the lowest levels of mobile internet penetration in the world—to identify the main factors that limit mobile broadband internet adoption. Results show that low levels of household consumption and prices of services are two key constraints. One standard

deviation increase in household expenditure, about US\$65 per capita per month, is associated with a 6.5 percentage point rise in the probability of adoption, while one standard deviation drop in the price of mobile internet services, about US\$3.60, increases the probability of adoption by 2.4 percentage points. Other determinants include demographic characteristics (sex, age, language, urban location), socioeconomic features (educational attainment, sector of employment), and other factors linked to policy (access to electricity, ownership of assets, alternative means of internet access). Results are robust to specifications focusing only in areas with mobile internet coverage (3G).

This paper is a product of the Poverty and Equity Global Practice. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at <http://www.worldbank.org/prwp>. The authors may be contacted at crodriguez@worldbank.org and tmasaki@worldbank.org.

The Policy Research Working Paper Series disseminates the findings of work in progress to encourage the exchange of ideas about development issues. An objective of the series is to get the findings out quickly, even if the presentations are less than fully polished. The papers carry the names of the authors and should be cited accordingly. The findings, interpretations, and conclusions expressed in this paper are entirely those of the authors. They do not necessarily represent the views of the International Bank for Reconstruction and Development/World Bank and its affiliated organizations, or those of the Executive Directors of the World Bank or the governments they represent.

Mobile Internet Adoption in West Africa

Carlos Rodríguez-Castelán^a

Rogelio Granguillhome Ochoa^b

Samantha Lach^c

Takaaki Masaki^d

Keywords: Internet adoption, mobile broadband, household consumption, West Africa

JEL codes: C25, C52, D12, L86, N3

The authors wish to thank Rita Armelle Oulai, Izak Atiyas, Calvin Bahia, Tania Begazo, Cesar Calderon, Pau Castells, Andrew Dabalén, Xavier Decoster, Toker Doganoglu, Mark Dutz, Vivien Foster, Tobias Pfutze, Emmanuel Skoufias, Daniel Valderrama, Estefania Vergara-Cobos, and Hernan Winkler for their comments and suggestions. The authors would also like to thank Tania Begazo, Brian Blankespoor, Niccolò Comini, Arthur Denis, Pascal Foch, Prospere Backiny-Yetna, and Djibril Ndoye for their support in accessing data. This study received funding from the Digital Development Partnership. The findings, interpretations, and conclusions in this paper are entirely those of the authors. They do not necessarily represent the views of the World Bank Group, its Executive Directors, or the countries they represent.

^a Lead Economist, Poverty and Equity Global Practice, World Bank (crodriguez@worldbank.org) (corresponding author).

^b Consultant, Poverty and Equity Global Practice, World Bank (rgranguillhomeoc@worldbank.org).

^c Consultant, Poverty and Equity Global Practice, World Bank (slach@worldbank.org).

^d Economist, Poverty and Equity Global Practice, World Bank (tmasaki@worldbank.org).

1. Introduction

Developing countries are in the process of harnessing digital technologies as a source of structural transformation and a pathway to accelerate economic growth (World Bank 2016). Recent years have seen a swift expansion in access to the internet, particularly across Sub-Saharan Africa. Unique mobile internet subscribers in the region, for example, have doubled in the last few years, reaching about 319.7 million in 2020.¹ However, the region still has the lowest mobile internet penetration in the world, at 27.7 percent of the total population, well below the world average of 51.2 percent. Notwithstanding the progress, there is evidence of a significant digital divide between Sub-Saharan Africa and the rest of the world (World Bank 2019). This gap in internet access is even broader within countries across socioeconomic groups and territories both in coverage and service quality. Rural households, poorer on average, have been found to face lower rates of internet access (Broadband Commission 2019). Being unable to access and use the internet can have serious implications for development, as suggested by recent evidence on the benefits of internet access and use, including digital financial inclusion, access to jobs, and greater household welfare (Bahia et al. 2020; Hjort and Poulsen 2019; Masaki, Granguillhome Ochoa, and Rodríguez-Castelán 2020; Suri and Jack 2016).

To maximize the potential benefit of the internet among households in Sub-Saharan Africa, it is a priority to identify the main constraints faced by individuals in adopting internet services. Most studies that analyze this issue identify demographic and socioeconomic characteristics, such as age, sex, educational attainment, wealth, digital literacy, and household size, as key factors associated with internet adoption. Only a few studies focus on mobile broadband (Hasbi and Dubus 2020; Kongaut and Bohlin 2016).² Others consider internet access from home (Coelho, Silva, and Ehrl 2019; Goldfarb and Prince 2008; Grazzi and Vergara 2014). Yet others do not distinguish among modalities of access, such as fixed broadband internet at home or outside the home or internet use through mobile broadband (Birba and Diagne 2012; Gillwald, Milek, and Stork 2010; Martínez-Domínguez and Mora-Rivera 2020; Nishijima, Ivanauskas, and Sarti 2017; Pénard et al. 2012, 2015). Of two studies identified that focus on mobile broadband, one relies on survey data on information and communication technology (ICT) use in Sweden (Kongaut and Bohlin 2016), while the other relies on household financial inclusion surveys in four Sub-Saharan African countries (Hasbi and Dubus 2020). In addition, studies on this issue generally neither account for the role that prices can play in mobile broadband adoption, nor incorporate the fact that there is no universal 3G coverage in most countries.³

This paper aims to identify the main drivers of mobile broadband adoption among individuals across West Africa, specifically in countries that belong to the West African Economic and Monetary Union (WAEMU).⁴ This subregion is an interesting case study for a number of reasons. First, most countries in the subregion are at the bottom of the global ranking on internet penetration, although Côte d'Ivoire

¹ The data in this and the next sentence are taken from GSMA Intelligence (database), Global System for Mobile Communications (GSM Association), London, <https://www.gsmainelligence.com/>. Accessed on November 2020.

² This constitutes an important gap since most people in developing countries, particularly in Sub-Saharan Africa, access the internet through mobile phones rather than through fixed broadband internet. Indeed, the number of active mobile broadband subscriptions per 100 inhabitants in Africa in 2019 was 34, compared with 0.4 in the case of fixed broadband subscriptions (ITU 2020).

³ Decoster et al. (2019) and Rodríguez-Castelán et al. (2019, 2021) show that greater competition in the ICT industry and, consequently, the lower prices for internet service would increase the number of users in the market for Djibouti, Ethiopia, and Mexico.

⁴ The eight WAEMU member countries are Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo. Because of data limitations, Burkina Faso has been excluded from the present analysis.

is closer to the global average.⁵ Second, despite low internet penetration, the subregion has shown a rapidly growing technology ecosystem, and increased internet adoption could complement the prospects of this economic transformation.⁶ Third, the prices of mobile data in these countries, adjusted for cost of living, are among the highest worldwide. For instance, Niger and Guinea-Bissau rank among the top 10 most expensive in the world in terms of the International Telecommunication Union's (ITU) data-only mobile broadband price basket.⁷ The prices are also high relative to other subregions in Africa. Thus, the average price of data-only mobile broadband stood at US\$8.50 in WAEMU countries (in nominal US dollars), compared with US\$5.50 in East Africa (ITU 2020).

This study takes advantage of harmonized microdata from the nationally representative 2018–19 Harmonized Survey of Household Living Conditions (Enquête Harmonisée sur les Conditions de Vie des Ménages, EHCVM) in each WAEMU member country.⁸ Each survey includes a direct question on the use of mobile internet. This information is rarely available in other household expenditure or consumption surveys in Africa. An advantage of using these surveys with respect to previous research derived from surveys on ICT use or from surveys on financial inclusion resides in the fact that the former include comprehensive expenditure and consumption data. In addition, data from these household surveys enabled this study to generate a proxy of the price of mobile internet services based on individual level expenditures on prepaid mobile phone cards and airtime/data transfers.⁹ Another advantage of these surveys is the harmonization of indicators across countries. This facilitates comparability and the aggregation of results. Finally, focusing on WAEMU countries that share a currency—the West African CFA franc—enables a direct cross-country comparison of the effects of consumption and prices on the decisions of individuals to adopt mobile internet. The analysis implements a simple discrete variable probabilistic model based on Goldfarb and Prince (2008).¹⁰

The results show that low household consumption and high price of mobile services are two key constraints on mobile broadband adoption across the subregion. A one standard deviation increase in household consumption, equivalent to CFAF 36,400 or about US\$65 per capita per month, is associated with an increase in the probability of mobile internet adoption of 6.5 percentage points.¹¹ And a decline in the price of mobile internet of CFAF 2,000 or about US\$3.60 per month is linked with an increase of 2.4 percentage points in the likelihood of adoption.¹²

⁵ The International Telecommunication Union (ITU) measures internet penetration according to the number of individuals using the internet as a share of the total population of a country. According to ITU data, five of the eight WAEMU countries are among the bottom decile in internet penetration globally. For the data, see WTI (World Telecommunication/ICT Indicators Database), International Telecommunication Union, Geneva, <https://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx>.

⁶ Benin and Burkina Faso have begun exhibiting some features of growing ecosystems, while Côte d'Ivoire is now West Africa's leading technology hub (20 active hubs), alongside Senegal (15 hubs), Mali (14), and Togo (13) (Giuliani and Ajadi 2019). Governments in the subregion are undertaking explicit reforms to encourage internet adoption and usage. The Government of Senegal, for instance, is implementing reforms aiming to expand internet usage through the *Stratégie Sénégal Numérique 2016–2025* (MENT 2016).

⁷ The data-only mobile broadband basket consists of a monthly data allowance of at least 1.5 GB, irrespective of the device used, over a 3G or higher network.

⁸ The survey program is a cooperative effort between WAEMU, the World Bank, and the national statistical institutes in the eight WAEMU countries. See Regional Program to Harmonize and Modernize Living Conditions Surveys (dashboard), World Bank, Washington, DC, <https://projects.worldbank.org/en/projects-operations/project-detail/P153702>.

⁹ The survey does not distinguish between airtime and data transfers.

¹⁰ Several other studies have also modeled adoption and usage as a two-stage probabilistic model (Grazzi and Vergara 2014; Kongaut and Bohlin 2016; Nishijima, Ivanauskas, and Sarti 2017; Martínez-Domínguez and Mora-Rivera 2020), while others center only on adoption (Hasbi and Dubus 2020).

¹¹ Based on an exchange rate of US\$1.00 = CFAF 555.45 in 2018. International Financial Statistics (database), International Monetary Fund, Washington, DC, <https://data.imf.org/?sk=4c514d48-b6ba-49ed-8ab9-52b0c1a0179b>.

¹² The monetary figure represents a value equivalent to a one standard deviation of the mobile data price proxy for the pooled sample.

In line with previous research, the results here show that demographic and socioeconomic characteristics also matter in internet adoption (sex, age, urban location, educational attainment, employment sector, and so on), as well as other variables linked with policy, such as access to electricity and other internet access modalities. Relative to men, women are associated with a 6.0 percentage point decrease in the probability of adoption, while urban residence increases the likelihood of adoption by 4.5 percentage points. These findings attest to both sex and urban-rural adoption gaps across WAEMU countries. The results also show that individuals ages 25–40 (versus individuals ages more than 40) and individuals with tertiary educational attainment (versus individuals with less than primary education) are more likely to adopt mobile broadband by 9.9 and 14.4 percentage points, respectively. Access to electricity is linked with an increase in adoption by 3.2 percentage points, which underlines the importance of the role of complementary infrastructure in mobile internet adoption. Employment in the service sector is associated with an increase of 4.8 percentage points in adoption, while working in agriculture decreases the likelihood of adoption by 3.1 percentage points. The analysis also finds that alternative modalities—such as access to the internet at work or at school—act as a complement to mobile broadband adoption.

The magnitude of the effects varies across countries in West Africa. Factors such as household consumption and sex are playing an expanding role in countries with higher internet penetration. For instance, in Senegal, an increase of one standard deviation in per capita expenditure is associated with an increase in internet adoption of 9.0 percentage points, compared with only 4.8 percentage points in Benin. Women in Côte d'Ivoire are less likely to adopt mobile internet by 7.3 percentage points, while the corresponding figure is 3.2 percentage points in Niger. Relative to less than primary educational attainment, tertiary educational attainment boosts the likelihood of adoption by 20.7 percentage points in Benin, but only by 7.9 percentage points in Mali. Individuals who are able to read and write in French—one of the main languages of digital content in the region—are 23.2 percentage points more likely to adopt mobile broadband in Côte d'Ivoire, compared with only 2.7 percentage points in Niger. The price elasticity of demand also varies across countries. A decrease in the price of mobile internet of CFAF 2,000, or about US\$3.60 per month is associated with a 3.4 percentage points increase in adoption in Guinea-Bissau and about a 1.0 percentage point increase in Niger.¹³ These results highlight the heterogeneity of the relative importance of barriers of adoption across countries.

The main results of the analysis are robust to three alternative model specifications. First, the findings hold for a selected sample that only includes those individuals living in a location where 3G (or higher) mobile internet is available. Second, the results are also robust to a two-stage process of adoption, incorporating data from 3G coverage maps.¹⁴ Third, results are consistent when estimating the model with an alternative measure of price based on the ITU price basket¹⁵ (compared to the results based on the price variable derived from the surveys).

This paper contributes to the existing literature in four ways. First, it expands the evidence base on a critical issue: barriers to mobile internet adoption across West Africa, one of the most poorly ranked areas in the world in terms of internet connectivity, and one of the least studied areas on this policy issue because of a lack of adequate microdata. Second, this work is among only a few studies that

¹³ The monetary data represent values equivalent to a one standard deviation of the mobile data price proxy for the pooled sample.

¹⁴ These alternative model specifications were tested for the case of Senegal, where access was available to a reliable contemporaneous map of mobile internet coverage that was integrated with household survey data. The same exercise was carried out for the remaining WAEMU countries using Collins Bartholomew signal coverage data. See Map Data Products (database), Collins Bartholomew, HarperCollins Publishers, Glasgow, <https://www.collinsbartholomew.com/map-data-products/>.

¹⁵ See IPB (ICT Price Baskets) (database), International Telecommunication Union, Geneva, <https://www.itu.int/net4/ITU-D/ipb/index.html>.

examine barriers to mobile broadband adoption in developing countries using microdata from household expenditure surveys integrated with coverage data of mobile broadband infrastructure. Household expenditure surveys have the advantage of measuring welfare more precisely than financial inclusion surveys or ICT use surveys, such as the Household and Individual ICT Access and Usage Survey of Research ICT Africa, which is employed by most internet adoption studies in Sub-Saharan Africa.¹⁶ Third, beyond examining the role of demographic and socioeconomic characteristics in the decisions of individuals to adopt mobile internet that dominates the literature on this topic, the analysis reported here includes key variables linked to policy, such as a well-measured metric of the purchasing power of individuals, the price of mobile internet services, complementary infrastructure, asset ownership, and local availability of 3G or 4G. Finally, the results test for potential bias given that 3G coverage is not universal across Sub-Saharan Africa. This has important implications because there are individuals living outside coverage areas who could afford mobile internet services, but do not have access to them, while others who live within coverage areas may decide not to adopt the services.

The findings highlight the importance of identifying internet adoption gaps both within and across developing countries. The results are also relevant in advancing the debate regarding the expansion of internet access, whereby adoption does not necessarily directly translate into usage. These findings are also informative for policy makers looking to prioritize internet access and connectivity as drivers of economic transformation and as an opportunity to target specific population groups and geographic areas that have been left out and are not yet reaping the gains of digital technologies.

The paper is organized as follows. Section 2 reviews the empirical and theoretical literature on internet adoption. Section 3 describes a framework to estimate mobile broadband adoption by households. Section 4 introduces the data sources used to carry out the empirical estimation, provides a brief overview of the ICT sector in WAEMU countries, and presents descriptive statistics. Section 5 supplies the results of the empirical application and the robustness checks. Section 6 delves into the policy implications. Section 7 concludes.

2. Literature review

Most of the literature on the drivers of the adoption and use of digital technologies has identified demographic and socioeconomic characteristics, such as income, age, sex, educational attainment, and household size, as the main factors of adoption. A study in rural Mexico shows that the probability of using the internet is higher among individuals who are younger, more well educated, and wealthier and who have knowledge of digital technologies, live in the northern (richer) part of the country, and have social networks (Martínez-Domínguez and Mora-Rivera 2020).¹⁷ Unlike other studies, the study in Mexico also finds a greater probability of using the internet among women. Self-reported data from an urban survey in Indonesia find that, while feature phones are owned by less well educated, older people (regardless of income level), the use of the internet on such phones is more prevalent among the younger and more well educated (Puspitasari and Ishii 2016). Focusing on seven Latin American countries, Grazzi and Vergara (2014) conclude that income, educational attainment, urban-rural location, household size, the presence of students in the household, and network effects are drivers of internet access, as is internet access across different modalities in some countries. Their study also points out that internet access does not guarantee usage, particularly among women. Nishijima, Ivanauskas, and Sarti (2017) find that educational attainment, which is associated with digital literacy,

¹⁶ See Household and Individual ICT Access and Usage Survey 2017–2018, World Bank, Washington, DC, <https://microdata.worldbank.org/index.php/catalog/3508>. The surveys are run by Research ICT Africa, Cape Town, South Africa.

¹⁷ Internet access and usage in this study refer to the presence of a fixed or mobile connection at home.

is the main barrier to the use of ICT in Brazil, alongside income, employment status, and the number of household members. Also using Brazilian data, Coelho, Silva, and Ehrl (2019) show that exogenous economic shocks have a negative impact on the demand for internet access at home, where this effect is stronger among households with lower levels of schooling and at the lower end of the income distribution.

Most research on Sub-Saharan Africa also focuses largely on socioeconomic and demographic factors. Based on data on Gabon, Pénard et al. (2012) find that educational attainment, English skills, and computer literacy, being male and having friends connected to the internet raise internet use, while age hinders adoption. Pénard et al (2015) find similar results in Cameroon. Based on data on 17 African countries, Birba and Diagne (2012) find that internet adoption is related to urbanization, internet infrastructure, and macroeconomic variables, in addition to individual characteristics such as sex, age, level of education, and social network membership. Using the same survey, Gillwald, Milek, and Stork (2010) show the existence of gender gaps in ICT access, specifically in those cases where individuals depend on public access, save for a few exceptions.¹⁸ Gender effects on adoption, however, become negligible if income, educational attainment, and employment status are held constant. Data on Nigeria suggest that men are 17 percent more likely than women to use the internet and that urban dwellers are 21 percent more likely than rural residents to have access (Gillwald, Odufuwa, and Mothobi 2018). Rural and poorer households in Africa exhibit lower internet access rates, and only capital cities and surrounding areas show high levels of access; other areas tend to lag (Frankfurter et al. 2020; Mahler et al. 2019).

Many of these studies, however, do not distinguish between means of internet access, such as fixed broadband internet at home or outside the home or mobile broadband (Birba and Diagne 2012; Gillwald, Milek, and Stork 2010; Martínez-Domínguez and Mora-Rivera 2020; Pénard et al. 2012, 2015; Nishijima, Ivanauskas, and Sarti 2017). Others focus simply on access to internet from home (Coelho, Silva, and Ehrl 2019; Goldfarb and Prince 2008; Grazzi and Vergara 2014). And only a few consider mobile broadband explicitly. One of these exceptions, a study based on data on Sweden, finds that richer, more well educated, and younger respondents are more likely to adopt phones with mobile broadband (Kongaut and Bohlin 2016). Another important exception in the context of this paper is a study on four Sub-Saharan African countries wherein the main determinants of mobile broadband adoption are ownership of a SIM card, ownership of a mobile phone, and the use of mobile money, while the people left behind tend to be lower-income, rural households and women (Hasbi and Dubus 2020). One of the limitations of this work, however, is that its models do not incorporate the fact that there is no universal 3G coverage across the region. Furthermore, for the most part, the studies surveyed do not consider the price of mobile broadband internet services as a factor in adoption.

Most of these research efforts are based on data from ICT use surveys (Coelho, Silva, and Ehrl 2019; Goldfarb and Prince 2008; Kongaut and Bohlin 2016; Martínez-Domínguez and Mora-Rivera 2020; Pénard et al. 2012, 2015), including two studies using the Household and Individual ICT Access and Usage Survey 2017–2018 of the Research ICT Africa network (Birba and Diagne 2012; Gillwald, Milek, and Stork 2010). Only a handful consider household surveys with different objectives, including a focus on financial inclusion (Grazzi and Vergara 2014; Hasbi and Dubus 2020; Nishijima, Ivanauskas, and Sarti 2017), only one of which centers on Sub-Saharan Africa. This distinction is

¹⁸ Cellphone ownership is higher among women than men in Mozambique and South Africa; while the same is true of internet literacy rates in Cameroon.

important because surveys on ICT use and financial inclusion tend to capture information on income (or consumption) through a single question (where the respondent chooses among established income brackets), unlike the meticulous work behind the household budget surveys used to measure poverty and other key welfare indicators. Sampling methods and sampling size also tend to be of better quality in household budget surveys. The advantages of household budget surveys, such as the ones utilized for the present study, over surveys of ICT use are key in the context of digital technologies, where income (or consumption) emerges as one of the most important factors in the adoption of mobile broadband.

Access to electricity and lower prices on mobile services driven by greater competition in the local ICT industry have also been shown to be major factors in internet adoption in poor countries. Using data on nighttime lights, Armev and Hosman (2016) find that expanding the distribution of electricity in low-income countries significantly increases the number of internet users. Another study shows that the type of household electricity supply, for example, the electricity grid, a generator, and so on, is one of the most important drivers of mobile phone ownership in Nigeria, alongside education, informal work, and employment status (Forenbacher et al. 2019). The existence of competitive environments among service providers also plays an important role in coverage, which is related to adoption. Recent studies on Djibouti and Ethiopia show that greater competition in digital infrastructure, such as a higher number of mobile operators and a reduction in the market power of broadband monopolies and oligopolies, can reduce prices and allow new entrants to adopt mobile services (Decoster et al. 2019; Rodríguez-Castelán et al. 2021). By estimating the likelihood of cell tower location relative to market size and installation and maintenance costs, Buys et al. (2009) find that competition has a positive and significant effect on cellphone coverage systems in Sub-Saharan Africa.

Another branch of the empirical literature looks at prices and variable or fixed costs as potential barriers to adoption. This research exploring the responsiveness of the demand for internet to changes in prices has focused on developed economies. Varian (2002) finds that individuals in the United States exhibit a greater willingness to pay for services through unmetered pricing systems than metered services and that most users place a low value on bandwidth (except individuals who telecommute). Liu, Prince, and Wallsten (2018) find a similar result. By analyzing the trade-offs among bandwidth, price, and data caps using US data, they discover that consumers also place a premium on unlimited data; the valuation of both bandwidth and data limits is concave. Based on cross-country data on the Organisation for Economic Co-operation and Development (OECD), Goel et al. (2006) demonstrate that the demand for internet services is price inelastic and that income elasticity is greater than unity, suggesting that internet services may not be a necessity.

Rigorous research using microdata can help gain a better understanding of the main constraints faced by households and individuals in developing countries in adopting digital technologies, particularly mobile broadband internet. Based on the literature, there seems to be a knowledge gap in the analysis on drivers of mobile internet adoption based on microdata from household expenditure surveys. Such analyses could measure individual welfare more precisely than surveys on ICT use, and also be applied to examine the role of prices on the decisions of individuals to adopt internet services.

3. Conceptual framework

To identify the main barriers to mobile broadband adoption in West Africa, the present study follows the model of Goldfarb and Prince (2008).¹⁹ It focuses on the decision whether or not to adopt mobile broadband internet, for which individuals would solve the following problem of utility maximization:

$$\begin{aligned} & \max_{I, M} u_i(I, M) \\ & s. t. pI + M \leq \bar{W}, \end{aligned} \quad (1)$$

where u denotes the utility derived by a representative consumer from mobile broadband internet and other goods. Specifically, I represents the consumption of mobile broadband internet, and M represents the general consumption of other goods by the individual. On the other hand, p represents the price of mobile broadband internet, while the price of the other goods consumed is a numeraire. \bar{W} represents the consumer budget constraint. Thus, the problem given by expression (1) can be rewritten as follows:

$$\max_I u_i(I, \bar{W} - pI) \quad (2)$$

Let I^* be the solution to the maximization problem, as follows:

$$\begin{aligned} I^* &= \operatorname{argmax}_I u_i(I, \bar{W} - pI) \\ &= I^*(\bar{W}, p) \end{aligned}$$

It then follows that the decision to access internet I^* is a function of the income (or consumption) of the individuals and the price of internet usage. Depending on each individual's preferences, the decision to consume mobile internet would also be a function of other relevant individual characteristics that could affect the utility function, such as skills, educational attainment, language, and other sociodemographic indicators. Then, the decision to adopt mobile broadband internet can be represented by the following condition:

$$\begin{aligned} & u_i(I_i^*, \bar{W}_i - pI_i^*) > u_i(0, \bar{W}_i) \\ \Leftrightarrow & u_i(I_i^*, \bar{W}_i - pI_i^*) - u_i(0, \bar{W}_i) > 0 \end{aligned} \quad (3)$$

Thus, the individual will adopt mobile broadband internet if and only if the difference (3) holds.

This framework can then be used to estimate the adoption of mobile broadband using a probit model, whereby an individual will adopt mobile broadband if the following is true:

$$u_i(I_i^*, \bar{W}_i - pI_i^*) - u_i(0, \bar{W}_i) = \beta_0 + \beta_1 \text{consumption}_i + \beta_2 \text{price}_j + X_i' \gamma + \varepsilon_i \geq 0, \quad (4)$$

Where X_i is a vector of individual-level controls, such as demographic characteristics, alternative means of internet access, complementary infrastructure, and ICT asset ownership. Furthermore,

¹⁹ Given this framework, the authors estimate usage and adoption by applying a type-II Tobit regression. To allow identification beyond a functional form, they include variables correlated with adoption but not usage in the first-stage equation. The authors implement the Heckman correction to control for the selection problem if either the instruments truly correlate with adoption (but not usage), or the first-stage error terms are normal. Type II Tobit regressions are also known as Heckit regressions. First, they estimate the probability of adoption, controlling for individual-level leisure time, income, and demographics. Second, under the premise, if and only if adoption takes place by the household, they estimate internet usage.

assuming ε_i is an individual-specific idiosyncratic error that is normally distributed, then the probability that the individual adopts mobile broadband internet is given by the following:

$$\begin{aligned} \Pr_i(\text{adoption}) &= \Pr(\beta_0 + \beta_1 \text{consumption}_i + \beta_2 \text{price}_j + X_i' \gamma + \varepsilon_i \geq 0) \\ &= \Phi(\beta_0 + \beta_1 \text{consumption}_i + \beta_2 \text{price}_j + X_i' \gamma) \end{aligned} \quad (5)$$

In a simplified form, the baseline model to estimate the determinants of internet adoption will take the form of the following probit model:

$$P(\text{adoption} = 1)_i = \Phi(\beta_0 + \beta_1 \ln(\text{consumption}_i) + \beta_2 \text{price}_j + X_i' \gamma), \quad (6)$$

where *adoption* is a binary variable that indicates whether an individual has access to mobile internet; *consumption* refers to the per capita household consumption of individual *i*; and *price* is the mobile internet services price for each country's region *j*.

The EHCVM 2018-19 household expenditure survey covers five distinct mechanisms through which individuals have access to the internet. One is through their mobile phones; while the remaining four refer to access to the internet (presumably through fixed broadband) at work, at school or university, at cybercafes, and at home. The present analysis focuses on internet access through mobile phones as the main variable of interest. Specifically, it defines the population that adopts mobile broadband as the individuals ages 15 or more who report that they access the internet through mobile telephone devices. The variables incorporated in the X_i vector include household size, urban residence, age, educational level, language, sex, and employment sector (agriculture, industry, services). Also included are the median age of the cellphone in the enumeration area, access to electricity, and the availability of televisions, computers, and tablets. Given that individuals can access the internet through complementary means, the vector also includes as variables the other four main mechanisms of internet access. The study derives a mobile internet services price proxy that combines positive expenditures on prepaid mobile phone cards and airtime/data transfers at the individual level among those individuals reporting that they have access to mobile internet. Finally, Φ refers to the standard normal cumulative distribution function.

Since 3G coverage in Sub-Saharan Africa is not universal, selection bias cannot be ruled out. To address the potential of selection bias in the adoption choice of individuals, the analysis implemented a maximum-likelihood two-stage Heckman selection probit model, first proposed by van de Ven and van Praag (1981), as a robustness check.²⁰ Under this specification, 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). Given that reliable 3G coverage data are available, the analysis modifies the main specification to estimate the probability that households have 3G coverage (selection equation), including the same set of covariates as previously, plus elevation and

²⁰ There is a strong case to be made for conceptualizing adoption as a two-stage process whereby households first need to live in 3G coverage areas and, subsequently, decide whether to adopt. This is particularly important in West Africa, where 3G coverage is not universal and tends to be concentrated in urban areas. However, given the limited potential bias deriving from non-randomness in the outcome variable, this robustness check is theoretical, rather than driven by nonrandom missing values in the outcome variable.

road density (Z) as the exclusion restrictions that affect 3G coverage, but not mobile broadband adoption.²¹ The selection equation thus reads as follows:

$$P(3G\ Coverage = 1)_i = \Phi(\beta_0 + \beta_1 \ln(consumption_i) + \beta_2 price_j + X_i' \gamma + Z' \mu) \quad (7)$$

Conditional on whether a household has 3G coverage or not, households now have to choose whether they adopt mobile broadband. Thus, for the second-stage model, the analysis estimates the probability of adopting mobile broadband services, conditional on 3G coverage and incorporating the selection term λ from the first stage as a covariate. The outcome equation therefore takes the form of the following probit specification:

$$P(Adoption = 1)_i = \Phi(\beta_0 + \beta_1 \ln(consumption_i) + \beta_2 price_j + X_i' \gamma + \lambda), \quad (8)$$

where the mean difference between the error terms of both equations (7) and (8) is zero, and both are not correlated.²² As an additional robustness check, the analysis compares the main results found to those based on a specification using linear probability models based on ordinary least squares regressions.²³

4. Brief overview of the ICT sector, data sources, and descriptive statistics

Stylized facts on mobile internet adoption in West Africa

Sub-Saharan Africa is the region with the lowest internet penetration in the world, at 18.7 percent, well below the world average of 49.0 percent.²⁴ The rate varies quite significantly across the region and also among WAEMU countries. For example, Côte d'Ivoire exhibits a relatively high rate (44.0 percent) close to the global average, while Guinea-Bissau has one of the lowest rates in the world (4.0 percent).²⁵ Over the past 15 years, Côte d'Ivoire has ranked first in coverage with respect to WAEMU countries. Yet, comparing WAEMU countries with South Africa, the leader in Africa, shows that the former must play catch-up.²⁶

Unique mobile internet subscribers tell a similar story.²⁷ Even though unique mobile internet subscribers increased almost twofold as a share of the population between 2014 and 2019 in the

²¹ For more information, see Ofcom (2018). Elevation and road density are used to proxy for cost factors that may influence the rollout of 3G coverage by cell phone providers. For example, mountainous areas are less likely to have cell phone towers, while areas with high road density would help reduce the cost of building 3G cell towers, given the existing infrastructure.

²² See Table 4 for the results of the Heckman corrected model.

²³ See Table A.1 in the [online appendix](#), which replicates the same analysis with the same set of covariates as reported in Annex Table 1 but with linear probability models instead of probit models.

²⁴ Data of 2017, WDI (World Development Indicators October 2020 Edition) (database), World Bank, Washington, DC, <https://datatopics.worldbank.org/world-development-indicators/>.

²⁵ Data are for 2017. The internet penetration rate is defined as the number of individuals using the internet as a percentage of the population. Internet users are those individuals who have used the internet (through any means, for example, a computer, mobile phone, personal digital assistant, gaming machine, digital television, and so on) over the previous three months. See WDI (World Development Indicators October 2020 Edition) (database), World Bank, Washington, DC, <https://datatopics.worldbank.org/world-development-indicators/>; WTI (World Telecommunication/ICT Indicators Database), International Telecommunication Union, Geneva, <https://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx>.

²⁶ Data of 2017, WDI (World Development Indicators October 2020 Edition) (database), World Bank, Washington, DC, <https://datatopics.worldbank.org/world-development-indicators/>.

²⁷ Given that consumers may use multiple SIM cards to take advantage of discounts or to avoid high charges for off-network calls, market penetration in terms of unique subscribers may provide a better picture of the degree of access to mobile services. GSMA defines

WAEMU subregion, per capita mobile broadband connections remain substantially below African leaders, such as South Africa. Furthermore, disparity persists among member countries in terms of broadband connections, despite relatively similar levels of 3G coverage. For instance, Guinea-Bissau lags behind Côte d'Ivoire with unique mobile internet subscriptions, at 15.4 percent of the population, compared with 28.0 percent in Côte d'Ivoire, even though both countries have similar levels of 3G coverage (around 90 percent).²⁸

WAEMU countries rank among the most expensive worldwide in terms of their mobile broadband data-only and low-usage voice-and-data price baskets.²⁹ In 2019, none of the WAEMU countries were on track to meet the 2025 affordability target in entry-level broadband services set by the Broadband Commission at less than 2 percent of monthly gross national income (GNI) per capita. Indeed, 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 GNI in Burkina Faso, 22.7 percent in Niger, and 28.8 percent in Guinea-Bissau in 2018 (ITU 2020). At the other end of the spectrum, the price of the same basket was 3.1 percent of per capita GNI in Senegal and 5.4 percent in Côte d'Ivoire in 2018, highlighting the heterogeneity that exists across WAEMU countries. Considering ITU's low-usage mobile voice-and-data services price basket, the subregion fares poorly. All but two countries (Côte d'Ivoire and Mali) have among the top 10 most expensive price baskets in the world. According to this ranking, Niger is the second most expensive country in the world, with a price basket as a share of GNI per capita hovering around 56.8 percent in 2018.

Data sources and descriptive statistics

The data used for this study are drawn from the EHCVM 2018-19 household expenditure surveys undertaken in each WAEMU country.³⁰ Besides being nationally representative, the surveys are representative in terms of urban and rural areas, as well as for the main regions or states in each country.³¹ A total of 52,306 households were interviewed, representing 173,092 individuals ages 15 or more. The sample size of each survey is comparable in magnitude across the WAEMU countries, and the questionnaire has been harmonized, allowing for comparability as well as the standardization of variables across countries. The microdata show that the share of individuals ages 15 or more that use mobile internet in the WAEMU subregion stands at 20 percent.³² Senegal has the largest share of individuals ages 15 or more who have access to mobile broadband (34.2 percent), followed by Côte d'Ivoire (24.4 percent). The country with the lowest share of connected individuals is Niger (at 7.6 percent). Annex, Table 1 provides descriptive statistics for the seven WAEMU countries analyzed.

Demographic and socioeconomic characteristics such as age, sex, sector of employment, language, and educational attainment, in addition to asset ownership variables (including median age of

mobile internet as the use of internet services by unique users on mobile devices at the end of a given period. Mobile internet services are defined as any activity that uses mobile data (that is, excluding SMS, multimedia messaging services, and cellular voice calls). See GSMA Intelligence (database), Global System for Mobile Communications (GSM Association), London, <https://www.gsmainelligence.com/>. Accessed on November 2020.

²⁸ See GSMA Intelligence (database), Global System for Mobile Communications (GSM Association), London, <https://www.gsmainelligence.com/>. Accessed on November 2020.

²⁹ The low-usage data-and-voice basket is composed of a monthly allowance of at least 70 minutes, 20 SMS, and 500 MB of data.

³⁰ See Regional Program to Harmonize and Modernize Living Conditions Surveys (dashboard), World Bank, Washington, DC, <https://projects.worldbank.org/en/projects-operations/project-detail/P153702>.

³¹ See Enquête Harmonisée sur les Conditions de Vie des Ménages (2018-19) (EHCVM), <http://www.uemoa.int/en/conditions-de-vie-des-menages-dans-les-etats-membres-de-l-uemoa-les-resultats-de-la-premiere-enquete>.

³² Access to mobile internet refers to those individuals who indicated in the EHCVM 2018-19 surveys that they use the internet through mobile phones.

cellphone at the enumeration area level, and whether the household owns a television, a computer, or a tablet), as well as access to electricity are derived from the survey.³³

Mobile coverage data are drawn from a digital mapping provider, Collins Bartholomew.³⁴ The chronological coverage of the data varies by 3G (2014–17) and 4G (2015–17). In the case of Senegal, the data are complemented by data obtained from mobile operators.³⁵

The level of reported mobile internet adoption obtained from the EHCVM 2018-19 survey is relatively similar to the estimates based on information from GSMA Intelligence, which sources its data from mobile operators' administrative registries.³⁶ Based on the sum of unique mobile internet subscribers in each country reported by the GSMA and dividing these by the sum of the population in each country, the WAEMU subregion had a mobile internet penetration rate of 24 percent during 2018/19. This is slightly above the 20 percent share among individuals ages 15 or more calculated using the EHCVM 2018–19 survey data.³⁷

A descriptive analysis of the EHCVM 2018-19 survey data in each country reflects the existence of important mobile broadband gaps, including by levels of consumption and rural or urban residence. At the subregional level, 32.5 percent of individuals above the median consumption threshold reported access to mobile internet, compared with only 10 percent of individuals living below the consumption threshold. There is considerable heterogeneity across countries. In the last place is Niger, where only 14.4 percent of individuals living in households above the median consumption threshold are connected to mobile broadband. This stands in contrast with Senegal, where about half of individuals who are members of households above the median consumption threshold are connected (annex, figure 1). Similar results can be seen in terms of a rural-urban divide. In the WAEMU subregion, 38.1 percent of individuals living in urban areas are connected to mobile broadband, compared with only 7.1 percent in rural areas (annex, figure 2). At the country level, Benin and Niger have the lowest levels of adoption in rural areas: 93.1 percent and 97.5 percent of individuals, respectively, are not connected to mobile broadband. While Senegal's share of rural dwellers who are not connected is lower, at 82.3 percent, the rate still reflects a steep rural-urban divide compared to the share of urban residents who are not connected (50.7 percent).

³³ These variables are defined at the household level. Cell phone age corresponds to the question "For how long have you owned the following item?"

³⁴ The data on mobile phone coverage and mobile broadband internet coverage compiled by Collins Bartholomew are based on two sources: (1) voluntary submissions directly emitted by mobile operators for the construction of roaming coverage maps for end users, and (2) open tower satellite estimations. See Map Data Products (database), Collins Bartholomew, HarperCollins Publishers, Glasgow, <https://www.collinsbartholomew.com/map-data-products/>.

³⁵ The data are provided by the three major mobile operators in the country: Expresso, Orange (or its local subsidiary Sonatel), and Tigo. Coverage data from Expresso and Tigo are only available for 2016, while Orange's data are available for 2016–18.

³⁶ See GSMA Intelligence (database), Global System for Mobile Communications (GSM Association), London, <https://www.gsmainelligence.com/>. Accessed on November 2020.

³⁷ The mismatch may be explained by the following factors: different population groups being examined (15+ years of age in the WAEMU survey versus the entire population in the GSMA Intelligence data); institutional mobile internet subscribers, such as firms and government agencies, being captured by GSMA's data; and measurement error stemming from respondents not fully knowing what mobile internet access entails, and from inactive users such as migrants. Across individual countries, the differences in mobile internet penetration as a share of the respective populations between the GSMA data and the EHCVM survey data is 5.5 percentage points, on average. Both Togo and Guinea-Bissau present the smallest gaps between metrics, at 1.7 and 3.1 percentage points, respectively. Mali and Benin show the largest differences in mobile adoption estimates between data sources, an 11 percentage point difference. These differences are significantly smaller than those shown by DIRSI data (<https://dirsi.net/web/web/en>), LIRNEasia (<https://lirneasia.net/>), and Research ICT Africa (database) (http://www.researchictafrica.net/ict_surveys.php), which exhibit differences of between 20 percent and 50 percent. For the GSMA data, see GSMA Intelligence (database), Global System for Mobile Communications (GSM Association), London, <https://www.gsmainelligence.com/>. Accessed on November 2020.

The largest gaps between connected and nonconnected individuals are found in terms of sex, educational attainment, and sector of employment. There is a 10 percentage point gender gap in mobile broadband access across the WAEMU subregion (annex, figure 3). At the country level, only 1 woman in 10 is connected to mobile broadband in Benin and Mali, compared with 1 in 5 in the case of men. In Senegal, 30.0 percent of women are connected, compared with 39.6 percent of men. In terms of education, the large majority (83.2 percent) of individuals with tertiary education are connected to mobile broadband at the subregional level, compared with 16.8 percent in the case of the less well educated (annex, figure 4). The large share of those with tertiary education who are connected is consistent across countries, with the exception of Guinea-Bissau, where it is slightly lower (at 66.5 percent). Among individuals without tertiary education, connectivity levels are more heterogeneous; adoption rates in Senegal are at 31.4 percent versus 6.4 percent and 11.4 percent in Niger and Benin, respectively.

The survey also sheds light on the importance of sectors of employment in mobile broadband adoption. Across the subregion, 37.0 percent of individuals working in the service sector are connected to mobile broadband, compared with only 14.6 percent of individuals working in agriculture or industry (annex, figure 5). In Niger, this gap is the widest, with 25.7 percent of individuals in the service sector connected, compared with only 4.9 percent in other sectors. The gap is narrowest in Senegal, where 46.0 percent of service sector employees are connected, compared with 29.5 percent in other sectors.

Because we do not observe directly the market prices of mobile internet faced by individuals in different regions within each country, the analysis approximates prices by using the unit value of individual level expenditures on prepaid mobile phone cards and airtime/data transfers reported in the data (Deaton 1987, 1988). This is a plausible assumption since these expenditures across West Africa exhibit a low degree of spatial variation and thus mobile internet services can be assumed to be a relatively homogeneous good (Gaddis 2016).³⁸ To produce this proxy, first, the median expenditure of prepaid mobile phone cards and transfers is calculated among mobile internet users in each country's geographic area at which the survey is representative—typically regions or states.³⁹ Next, this unit value is computed as a share of total consumption at the same geographic level to adjust for cost of living. This value is then imputed to each individual observed in the survey data.

This price proxy of mobile data stood at CFAF 5,052 (US\$9.10) per month on average across the WAEMU subregion in 2018/19. This is equivalent to an average of 15.0 percent of total per capita expenditure. Senegal presents the most affordable price as a share of total per capita expenditure (12.8

³⁸ We calculated the coefficient of variation of expenditures on prepaid mobile phone cards and airtime/data transfers for each of the 93 geographic units to check whether it is plausible to assume that mobile internet services is an homogeneous good (see Table A.2 in the [online appendix](#)). Across the entire sample, the average coefficient of variation is 79.1 percent (with a median of 78.2 percent), and there is significant variation from the mean. The coefficient of variation computation excludes outliers with reported prices of prepaid mobile phone cards and airtime/data transfers above two standard deviations from the country-region mean. Besides this variability in unit values, one would also expect mobile services to behave as homogeneous goods in a subregion such as West Africa, where 97 percent of mobile connections are prepaid and the main mechanism of internet access is through mobile phones. According to the ITU for West Africa, fixed broadband subscriptions in 2019 stood at 0.2 percent of the total population versus unique mobile internet subscribers, which amounted to 28.6 percent of the total population based on data of GSMA Intelligence. Prepaid connection data is also derived from GSMA Intelligence. See GSMA Intelligence (database), Global System for Mobile Communications (GSM Association), London, <https://www.gsmainelligence.com/>. Date accessed November 2020; WTI (World Telecommunication/ICT Indicators Database), International Telecommunication Union, Geneva, <https://www.itu.int/en/ITU-D/Statistics/Pages/publications/wtid.aspx>.

³⁹ The analysis excludes values that lie above two standard deviations away from the country-region mean of prepaid mobile phone cards and airtime/data transfers.

percent), followed by Côte d'Ivoire (at 12.9 percent). At the higher end of the distribution, Mali had the most expensive price bundle in the subregion (21.8 percent), followed by Togo (17.1 percent).⁴⁰ Within countries, regions encompassing the capital city or large urban agglomerations, such as Abidjan in Côte d'Ivoire and Dakar in Senegal, tend to present the most affordable (lowest) prices as a share of total expenditure. The price proxy can also be validated against a set of ITU price indicators. The comparison shows that the price metric is slightly above the price reported by the ITU in terms of a data-only mobile broadband basket. According to ITU data, the subregion had an average monthly data-only broadband price basket of CFAF 4,713, which is slightly lower but close to the survey-derived price estimate.⁴¹

5. Results

The analysis estimated the model aggregated at the subregional level as well as on a country-by-country basis. The results on the main specification by country and on the pooled subregional sample are presented in annex, tables 2 and 3. Table 2 shows the point estimates of the probit model. Table 3 displays average marginal effects.⁴² Annex, figure 6 provides a coefficient plot that summarizes the main results (average marginal effects).

The results show that low levels of household consumption and the higher price of services are among the main constraints on mobile broadband adoption across the WAEMU countries. In addition, they show that adoption is associated with factors along three main categories. These are demographic characteristics (age, sex, language, location) and socioeconomic characteristics (education, employment sector), which are in line with previous research, as well as policy-related factors (access to electricity, asset ownership, alternative modalities of access). Overall, the results show that the drivers of adoption tend to play an increasingly bigger role in countries with higher internet penetration. The results are consistent across countries and in the pooled sample in terms of both the sign of the coefficient and statistical significance (see below).

Higher household consumption and lower prices are associated with higher adoption rates across the WAEMU countries. An average standard deviation increase in household consumption (CFAF 36,400 per capita or about US\$65 per month) is linked with a rise in mobile internet adoption of 6.5 percentage points in the subregion. At the country level, household consumption plays the most significant role in Senegal, where a one standard deviation increase in household consumption (CFAF 40,000 or about US\$72 per month) is associated with a 9.0 percentage point increase in adoption (annex, Table 3). In Niger, meanwhile, a one standard deviation increase in household consumption (CFAF 21,000 or US\$38 per month) is associated with only a 3.5 percentage point increase in adoption. In terms of affordability, an average decline in the price of mobile data of CFAF 2,000 or

⁴⁰ For the remaining three countries, the unit price averaged 15.0 percent of total per capita expenditures.

⁴¹ At the country level, the difference between estimates from the two sources hovers around CFAF 1,997 (US\$3.50). In Senegal, the basket price, according to ITU data, was CFAF 2,000 (US\$3.60), compared with CFAF 4,711 (US\$8.50) according to the EHCVM 2018–19 survey. As an extra validation test, the analysis compared the survey-derived price variable with data obtained directly from Senegalese mobile operators. In 2018, the cheapest monthly mobile data plan offered by the operator with the largest market share (Orange) was CFAF 5,000, compared with CFAF 4,711 for the survey-derived price. For the ITU data, see IPB (ICT Price Baskets) (database), International Telecommunication Union, Geneva, <https://www.itu.int/net4/ITU-D/ipb/index.html>.

⁴² Because of the nonlinear nature of the probit model employed, marginal effects are not easily derived from the estimated coefficients, as discussed in Grazi and Vergara (2014). For (log) per capita expenditure, price, and household size, average marginal effects are calculated based on a one unit increase in the standard deviation. These effects should be interpreted with caution as there are instances (primarily where there is a low degree of variability in the control variable) in which the coefficient loses significance in the calculation of average marginal effects. These are not reported in the text.

about US\$3.60 per month is associated with an increase in adoption of 2.4 percentage points across the subregion.⁴³ At the country level, Guinea-Bissau is the most responsive to changes in prices, whereby a price decline of the same magnitude is linked with an increase in the likelihood of adoption by 3.4 percentage points. In Niger, a price drop of the same magnitude is associated with a 1.0 percentage point increase in the probability of adoption, displaying a more inelastic response.⁴⁴

The first category of variables, demographic characteristics (location, age, sex, language, household size), plays an important role. Across the full sample, individuals in urban households are 4.5 percentage points more likely than rural residents to adopt mobile broadband. Urban location has the lowest association with adoption in Niger, increasing adoption by 3.3 percentage points, and the highest in Togo, where individuals in urban areas see their probability of adoption rise by 8.0 percentage points. In terms of age, the 25–40 age-group is associated with an increase in the likelihood of adoption in all countries. Across the full sample, individuals in this age bracket are 10.0 percentage points more likely to adopt mobile broadband than people ages more than 40.⁴⁵ Female sex is associated with a decline of 6.0 percentage points in the probability of adoption across the pooled sample; every country analyzed exhibits a negative and highly significant coefficient under the baseline specification. Women are linked with a decrease in the probability of adoption by 7.3 and 8.0 percentage points in Côte d'Ivoire and Benin, respectively. In Niger and Mali, the magnitude of the barrier is smaller, but still significant, lowering the probability of adoption by 3.2 and 4.7 percentage points, respectively.

Language 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 phone across the entire sample.⁴⁶ Language is particularly important in Côte d'Ivoire, where individuals who can read and write in French are 23.2 percentage points more likely to adopt, compared with those who cannot read or write in French or who are illiterate. Across the full sample, larger household size is linked with a higher likelihood of adoption.

The second category, socioeconomic characteristics, such as education level and labor sector (in addition to household consumption), is also significantly associated with adoption. Across the EHCVM 2018–19 sample, individuals with tertiary education are 14.4 percentage points more likely than people with less than primary education to adopt mobile broadband. Tertiary educational attainment is associated with a 20.7 percentage point rise in the probability of adoption in Benin, where the effect is greatest, and with a 7.9 percentage point increase in Mali, where the effect is weakest.⁴⁷

Working in agricultural jobs is associated with a decline of 3.1 percentage points in the probability of adoption with respect to the unemployed and individuals not actively participating in the labor force. This result is consistent across the WAEMU countries, except Niger (annex, Table 2 and 3).

⁴³ The monetary values are equivalent to a one standard deviation of the mobile data price proxy for the pooled sample.

⁴⁴ For the remaining countries, the associated increase in the likelihood of adoption stemming from a price drop ranges between 1.4 and 3.2 percentage points.

⁴⁵ Individuals ages 15–24 are also more likely to adopt mobile broadband internet relative to people ages more than 40 in all countries, except Benin and Togo. Across the sample, these individuals are 6.1 percentage points more likely to adopt mobile broadband. This effect is greatest in Senegal, where it increases the likelihood of adoption by 15.1 percentage points, and weakest in Niger, at 2.6 percentage points.

⁴⁶ In Guinea-Bissau, the language of reference is Portuguese.

⁴⁷ The associated impact of tertiary education on mobile broadband adoption in the remaining countries ranges between 13.1 and 16.7 percentage points.

Conversely, those employed in the services sector are 4.8 percentage points more likely to adopt relative to individuals who are unemployed or not actively participating in the labor force across the full sample. Employment in services is most strongly associated with adoption in Senegal (8.2 percentage points), whereas, in Mali, the effect is the smallest (3.2 percentage points). In Guinea-Bissau, working in services is linked to an increase in adoption of 4.2 percentage points, while employment in agriculture decreases the likelihood of adoption by 3.7 percentage points.

The third category consists of factors that can be characterized as policy related, including electricity, asset ownership, and alternative modalities of access (in addition to prices). The results show that access to electricity is linked with a 3.2 percentage point rise in adoption across the full sample. It is particularly important in Senegal, where it is associated with a 6.1 percentage point increase in adoption. In all countries, except Guinea-Bissau, Mali and Niger, access to electricity is significantly and positively associated with mobile broadband internet adoption. In terms of assets, owning a television is significantly and positively associated with mobile broadband internet in all countries. It has the highest association with adoption in Senegal (9.0 percentage points) and Togo (7.3 percentage points) and the lowest in Mali and Côte d'Ivoire (3.0 percentage points). The results are less consistent in terms of tablets and computers.⁴⁸ This may be linked to the low levels of computer and tablet ownership across the WAEMU countries, which stood at 5.0 percent and 2.0 percent, respectively.

One contribution of this paper to the literature is the inclusion of alternative means of internet access, which may complement or substitute for mobile broadband adoption. The EHCVM 2018–19 survey covers four means of access (internet at home, work, school or university, and cybercafes), in addition to access through mobile phones. Across the subregion, each mechanism of access is highly significant. Access to internet at work shows the greatest association with increased adoption, by 11.9 percentage points.⁴⁹ Access to the internet at home or in school/university is associated with an increase in the probability of adoption of 10.7 and 9.2 percentage points, respectively.⁵⁰ Accessing the internet in cybercafes shows mixed results in adoption. It is linked with a rise in the probability of adoption of 5.3 percentage points in the subregion and of 4.3 and 8.4 percentage points, respectively, in Côte d'Ivoire and Togo. Yet, in Senegal, accessing the internet at cybercafes acts as a substitute for mobile broadband and is associated with a decrease in the probability of adoption by 14.4 percentage points.⁵¹

Given the heterogeneity in WAEMU country characteristics, additional model specifications were carried out. First, the main results were compared with the results using linear probability models. The main results are robust to this different model specification in both each country and the pooled subregion.⁵² The findings are also robust to the analysis of various subsamples of the data.⁵³

The results are robust to additional specifications following a two-stage process of adoption, wherein the first stage depends on living in an area with 3G coverage. Under this specification, a fundamental

⁴⁸ Owning a computer has a positive and significant association with adoption in Benin, Côte d'Ivoire, and Niger; while tablet ownership only has an association with adoption in Côte d'Ivoire, Guinea-Bissau, and Niger.

⁴⁹ Access to internet in the workplace shows a significant association in all countries. The effect is greatest in Togo and Senegal, linked to an increase in the probability of adoption of 29.6 and 17.7 percentage points, respectively. In Benin and Côte d'Ivoire, it has the lowest magnitude and is linked to an increase in adoption of 11.5 and 7.7 percentage points, respectively.

⁵⁰ Access to the internet at school or university is significantly linked to increased adoption in all WAEMU countries, except Senegal and Mali. Only Côte d'Ivoire, Mali, Niger, and Senegal show a significant, positive association between access at home and adoption.

⁵¹ No associated effects were found on this modality of access in the other countries.

⁵² See Table A.1 in the [online appendix](#).

⁵³ The entire sample was split by sex, urban location, median household income, median age, literacy, labor force participation, language, employment status, and education level. See Table A.3 in the [online appendix](#).

relationship is assumed between households covered by 3G (first stage) and households that decide to adopt mobile broadband (second stage). The findings are consistent with those of the main specification (annex, Table 4).

An additional robustness check based on a Heckman-corrected probit and using the higher-quality coverage data of mobile service providers can be derived for Senegal (annex, Table 5). The results are consistent with those of the preferred specification and the specification using the Collins Bartholomew 3G coverage data. An extra test was conducted by censoring the sample conditional to individuals living in 3G coverage areas in Senegal only. The main findings are robust to this specification, too.

The analysis also involved a robustness check on the degree of accuracy of the mobile internet price variable. Thus, the mobile internet price variable was replaced with ITU's data-only mobile broadband price basket in the preferred specification, which yields results that are consistent with the main estimates (annex, Table 6).⁵⁴ Across the subregion, an average decline in the ITU price basket by one standard deviation is linked with an increase in adoption of 4.9 percentage points. An analogous decline in the survey-derived mobile internet price is associated with a 2.4 percentage point increase in adoption. Niger is among the least responsive countries to a change in price; there, a decline of the same magnitude in the ITU price basket is linked with an increase in the likelihood of adoption by 1.3 percentage points. This is similar to the result of an analogous decline in the survey-derived price variable in the country, which is associated with a 1.0 percentage point increase in the likelihood of adoption.

6. Policy discussion

The results show that two of the main constraints on mobile broadband adoption across West Africa are low levels of household consumption and the high price of mobile internet services. The findings are also consistent with the previous literature showing that demographic and socioeconomic factors as well as complementary infrastructure are also important factors in internet adoption, including urban location, sex, age, tertiary educational attainment, language, and access to electricity.

Policies to ease these constraints are a necessary first step to promoting digital uptake. Interventions geared toward the universal coverage of 3G mobile services can be consequential in reaching excluded populations, such as people in remote rural areas. Government policies that reduce budget constraints on households, such as vouchers or direct social assistance transfers, can also help improve access to mobile broadband services. Because the WAEMU countries present some of the highest mobile data prices in the world, implementing reforms to boost competition in service provision and investment in digital infrastructure can help reduce the prices of mobile internet services, especially among users at the lowest incomes. Policies could also aim at reducing the operational costs of operators, such as through a reduction of taxes and fees (Pedros and Sivakumaran 2019) and the implementation of rules for infrastructure sharing, roaming and co-investment. Increasing the availability of affordable digital infrastructure, especially in rural areas, coupled with enhanced electricity availability, is key to countering the risk of a widening digital divide. Other initiatives among phone manufacturers, mobile network operators, and the government, such as building low-cost smartphones, zero-cost messaging and mobile social media services, and exempting less-expensive smartphones from taxes and import tariffs, can also help increase access to mobile internet devices (CGAP 2016). Some initiatives from

⁵⁴ For simplicity, only probit regression results are shown.

the private sector include the co-financing of devices for consumers through direct subsidies or financing schemes within their business models.

These measures, nonetheless, may be insufficient to facilitate the adoption of digital technology for all. As highlighted by the results, beyond the budget constraints, there are other barriers to the adoption of digital technology. Some of these have also been explored in the literature. They include low educational attainment, lack of digital (computer) skills, and lack of knowledge of English or French (Birba and Diagne 2012; Martínez-Domínguez and Mora-Rivera 2020; Pénard et al. 2012, 2015; Puspitasari and Ishii 2016). Policy design needs to reflect a consideration that adoption does not directly translate into usage for everyone, and attention also must be tailored to vulnerable groups.

The results reflect the existence of a gender gap in the adoption of mobile internet. Across all WAEMU countries examined, women are less likely than men to access the internet through mobile devices. This attests to the need for gender-specific approaches to promote the adoption of digital technology. 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 (GSMA 2020).

The results also suggest that literacy in the main national language used online is associated in all countries with a significant increase in the likelihood of adoption. This reflects the importance of improving literacy and of policies promoting local language content. A language mismatch can prevent ICT usage and even support a misconception about the potential benefits of technology (Grazzi and Vergara 2012). Future work might look at the relevance of digital content and language. Ideally, the analysis would factor in local languages at a more granular level to determine their overall effects on adoption relative to French (or Portuguese in the case of Guinea-Bissau).

Another dimension that merits attention is the role that education and skills play in adoption. Many African countries have seen a drastic increase in school enrollments in recent years. This raises a question about the extent (if any) of the association between the enrollment numbers and digital literacy. Significant improvements in educational indicators have been made across countries, such as the rise in enrollment in tertiary education.⁵⁵ And the results presented here indeed show that having tertiary education is associated with an increase in mobile internet adoption. At the same time, many of these efforts do not appear to have translated into higher literacy, which could serve as a catalyst for digital skills, especially among women and older cohorts. Digital literacy is likewise an important foundation to help reduce existing gaps in the adoption (and potential use) of digital technologies. The finding of this study that internet access at school or university is associated with an increase in the likelihood of mobile broadband adoption highlights the importance of investing in infrastructure and increasing coverage in targeted sectors.

The results also highlight a link between sector of employment and adoption, with large differences between work in agriculture and the service sector. Employment in the service sector is positively associated with adoption, while working in agricultural jobs decreases the likelihood of adoption. This is especially relevant considering that, across the WAEMU countries sampled, approximately half the individuals are employed in agriculture. Yet, only 4 percent of these individuals have access to mobile broadband. This stands in stark contrast with what happens in the service sector, which accounts for 36 percent of those employed and represents 37 percent of the individuals who have access to mobile

⁵⁵ Data of 2020, WDI (World Development Indicators October 2020 Edition) (database), World Bank, Washington, DC, <https://datatopics.worldbank.org/world-development-indicators/>.

broadband. The results also show that internet access at work is a complement to mobile broadband adoption in all countries. These findings suggest that more attention needs to be placed on digitization and access to the internet in the agricultural sector. This could help reduce the urban-rural digital divide and boost productive inclusion in rural areas by reducing the cost of agricultural inputs and expanding the market access of small farmers to increase sales (Masaki, Raja, and Rodríguez-Castelán 2021).

7. Conclusion

The widespread adoption and use of digital technologies have multifold potential benefits: from improving financial inclusion through mobile money applications to enhanced access to job opportunities and from the more effective delivery of basic services through e-government applications to expanding access to markets through e-commerce. None of these benefits, however, can be realized without first adopting the internet.

This paper identifies the main drivers of the adoption of mobile broadband internet among individuals in West Africa by exploiting data of the 2018–19 nationally representative *Enquête Harmonisée sur les Conditions de Vie des Ménages* (EHCVM 2018–19). The value added of this study includes (1) expanding the evidence-base on the barriers to mobile internet adoption, a crucial issue in an area of the world that has the largest gaps in mobile internet coverage, adoption, and use; (2) the use of comprehensive microdata from household expenditure surveys to analyze the effect of household consumption and the prices of mobile services and that also allows ready comparison across countries because the data are harmonized across a monetary union; (3) the inclusion of policy-related variables to study the factors behind the decisions of individuals to adopt mobile internet, in addition to socioeconomic and demographic characteristics; and (4) taking into account that 3G coverage is not universal across countries in Sub-Saharan Africa and controlling for sample selection by integrating 3G coverage maps from mobile service operators.

The study concludes that low levels of household consumption and the relatively high price of mobile services are key constraints on internet adoption by individuals. The findings are consistent with previous studies on other key drivers of adoption, including urban location, age, sex, tertiary educational attainment, language, asset ownership, and access to electricity. Unlike previous studies, the analysis involved robustness checks to various specifications, including treating the decision to adopt mobile internet as a two-stage process, wherein the first stage depends on living in an area with 3G coverage. The results are robust to these alternative specifications.

Increasing mobile broadband adoption in Sub-Saharan Africa can have substantial direct and spillover effects, particularly among the most vulnerable socioeconomic groups. Expanding and improving the availability of affordable digital infrastructure, particularly in rural areas, and policies geared toward the universal coverage of 3G mobile services are key to mitigating the risk of a widening digital divide. To promote digital adoption and in parallel to expanding coverage, it is crucial to ease the budget constraints on households and foster competition in the ICT industry to converge to competitive pricing in services and assets. Finally, it should also be a policy priority to address other potential hurdles to the adoption of mobile internet, such as those related to digital literacy, access to electricity, and the barriers faced by women and farmers, which could hamper the adoption of digital technologies, particularly in poorer, rural areas.

References

- Armeý, Laura E., and Laura Hosman. 2016. "The Centrality of Electricity to ICT Use in Low-Income Countries." *Telecommunications Policy* 40 (7): 617–27.
- Bahia, Kalvin, Pau Castells, Genaro Cruz, Takaaki Masaki, Xavier Pedrós, Tobias Pfitze, 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.
- Birba, Ousmane, and Abdoulaye Diagne. 2012. "Determinants of Adoption of Internet in Africa: Case of 17 Sub-Saharan Countries." *Structural Change and Economic Dynamics* 23 (4): 463–72.
- Broadband Commission (United Nations Broadband Commission for Sustainable Development). 2019. *Connecting Africa through Broadband: A Strategy for Doubling Connectivity by 2021 and Reaching Universal Access by 2030*. October. Geneva: Broadband Commission Working Group on Broadband for All, International Telecommunication Union. https://www.broadbandcommission.org/Documents/working-groups/DigitalMoonshotforAfrica_Report.pdf.
- Buys, Piet, Susmita Dasgupta, Timothy S. Thomas, and David Wheeler, 2009. "Determinants of a Digital Divide in Sub-Saharan Africa: A Spatial Econometric Analysis of Cell Phone Coverage." *World Development* 37 (9): 1494–1505.
- CGAP (Consultative Group to Assist the Poor). 2016. *Market System Assessment of Digital Financial Services in WAEMU*. Washington, DC: World Bank.
- Coelho Florângela Cunha, Thiago Christiano Silva, and Philipp Ehrl. 2019. "Internet Access in Brazilian Households: Evaluating the Effect of an Economic Recession." In *New Knowledge in Information Systems and Technologies*, vol. 2, edited by Álvaro Rocha, Hojjat Adeli, Luís Paulo Reis, and Sandra Costanzo, 716–25. Advances in Intelligent Systems and Computing Series, vol. 931. Cham, Switzerland: Springer.
- Deaton, Angus S. 1988. "Quality, Quantity, and Spatial Variation of Price." *American Economic Review* 78 (3): 418–30.
- Deaton, Angus S. 1997. *The Analysis of Household Surveys: A Microeconomic Approach to Development Policy*. Washington, DC: World Bank; Baltimore: Johns Hopkins University Press.
- Decoster, Xavier, Gabriel Lara Ibarra, Vibhuti Mendiratta, and Marco Santacroce. 2019. "Welfare Effects of Introducing Competition in the Telecom Sector in Djibouti." Policy Research Working Paper 8850, World Bank, Washington, DC.
- Forenbacher, Ivan, Siniša Husnjak, Ivan Cvitić, and Ivan Jovović. 2019. "Determinants of Mobile Phone Ownership in Nigeria." *Telecommunications Policy* 43 (7), 101812.
- Frankfurter, Zoe, Klaudia Kokoszka, David Locke Newhouse, Ani Rudra Silwal, and Siwei Tian. 2020. "Measuring Internet Access in Sub-Saharan Africa (SSA)." Poverty and Equity Notes 31 (August), World Bank, Washington, DC. <https://openknowledge.worldbank.org/bitstream/handle/10986/34302/Measuring-Internet-in-Access-in-Sub-Saharan-Africa-SSA.pdf?sequence=1>.
- Gaddis Isis. "Prices for Poverty Analysis in Africa." Policy Working Paper 7652, World Bank, Washington, DC.
- Gillwald, Alison, Anne Milek, and Christoph Stork. 2010. "Towards Evidence-Based ICT Policy and Regulation Gender Assessment of ICT Access and Usage in Africa." With Robertine Tankeu, Woldekedian Amde, Norah Mulira, Mbombo Malema, and Ike Mowete. RIA Policy Paper 1 (5), Research ICT Africa, Cape Town, South Africa.
- Gillwald, Alison, Fola Odufuwa, and Onkokame Mthobi. 2018. "The State of ICT in Nigeria." Policy Paper 3, Series 5, Research ICT Africa, Cape Town, South Africa.
- Giuliani, Dario, and Sam Ajadi. 2019. "618 Active Tech Hubs: The Backbone of Africa's Tech Ecosystem." *Ecosystem Accelerator* (blog), July 10, 2019. <https://www.gsma.com/mobilefordevelopment/blog/618-active-tech-hubs-the-backbone-of-africas-tech-ecosystem/>.
- Goel, Rajeev K., Edward T. Hsieh, Michael A. Nelson, and Rati Ram. 2006. "Demand Elasticities for Internet Services." *Applied Economics* 38 (9): 975–80.
- Goldfarb, Avi, and Jeff Prince. 2008. "Internet Adoption and Usage Patterns Are Different: Implications for the Digital Divide." *Information Economics and Policy* 20 (1): 2–15.

- Grazzi, Matteo, and Sebastián Vergara. 2012. "ICT in Developing Countries: Are Language Barriers Relevant? Evidence from Paraguay." *Information Economics and Policy* 24 (2): 161–71.
- 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). 2020. "Connected Women: The Mobile Gender Gap Report 2020." GSMA, London. <https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2020/05/GSMA-The-Mobile-Gender-Gap-Report-2020.pdf>.
- Hasbi, Maude, and Antoine Dubus. 2020. "Determinants of Mobile Broadband Use in Developing Economies: Evidence from Sub-Saharan Africa." *Telecommunications Policy* 44 (5): 101944. <https://doi.org/10.1016/j.telpol.2020.101944>.
- 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.
- Kongaut, Chatchai, and Erik Bohlin. 2016. "Investigating Mobile Broadband Adoption and Usage: A Case of Smartphones in Sweden." *Telematics and Informatics* 33 (3): 742–52.
- Liu, Yu-Hsin, Jeffrey Prince, and Scott Wallsten. 2018. "Distinguishing Bandwidth and Latency in Households' Willingness-to-Pay for Broadband Internet Speed." *Information Economics and Policy* 45 (December): 1–15.
- Mahler, Daniel Gerszon, Jose Montes, and David Locke Newhouse. 2020. "Internet Access in Sub-Saharan Africa (SSA)." *Poverty and Equity Notes* 13 (March), World Bank, Washington, DC.
- 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.
- Masaki, Takaaki, Chandni Raja, and Carlos Rodríguez-Castelán. 2021. "Mobile Internet and Agricultural Productivity in Nigeria." World Bank, Washington, DC.
- MENT (Ministère de l'Economie Numérique et des Télécommunications, Ministry of Digital Economy and Telecommunications, Senegal). 2016. "Stratégie: Sénégal Numérique 2016–2025." October, MENT, Dakar, Senegal. <https://www.sec.gouv.sn/sites/default/files/Strat%C3%A9gie%20S%C3%A9n%C3%A9gal%20Num%C3%A9rique%202016-2025.pdf>.
- Nishijima, Marislei, Terry Macedo Ivanauskas, and Flavia Mori Sarti. 2017. "Evolution and Determinants of Digital Divide in Brazil (2005–2013)." *Telecommunications Policy* 41 (1): 12–24.
- Ofcom (Office of Communications). 2018. "Economic Geography 2018: An Analysis of the Determinants of 3G and 4G Coverage in the UK." December 18, Ofcom, London.
- Pedros, Xavier and Mayuran Sivakumaran. 2019. "Rethinking mobile taxation to improve connectivity. Global System for Mobile Communications" February 2019. www.gsma.com/publicpolicy/wpcontent/uploads/2019/02/Rethinking-mobile-taxation-to-improve-connectivity_Feb19.pdf
- Pénard, Thierry, Nicolas Poussing, Blaise Mukoko, Georges Bertrand, and Tamokwe Piaptie. 2015. "Internet Adoption and Usage Patterns in Africa: Evidence from Cameroon." *Technology in Society* 42 (August): 71–80.
- Pénard, Thierry, Nicolas Poussing, Gabriel Zomo Yebe, and Philémon Nsi Ella. 2012. "Comparing the Determinants of Internet and Cell Phone Use in Africa: Evidence from Gabon." *Communications and Strategies* 1 (86): 65–83.
- 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, Abdelkrim Araar, Eduardo A. Malásquez, Sergio Olivieri, and Tara Vishwanath.

2019. "Distributional Effects of Competition: A Simulation Approach." Policy Research Working Paper 8838, 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.
- van de Ven, Wynand P. M. M., and Bernard M. S. van Praag. 1981. "The Demand for Deductibles in Private Health Insurance: A Probit Model with Sample Selection." *Journal of Econometrics* 17 (2): 229–52.
- Varian, Hal R. 2002. "The Demand for Bandwidth: Evidence from the INDEX Project." In *Broadband: Should We Regulate High-Speed Internet Access?*, edited by Robert W. Crandall and James H. Alleman, 39–56. Washington, DC: AEL-Brookings Joint Center for Regulatory Studies.
- World Bank. 2016. *World Development Report 2016: Digital Dividends*. Washington, DC: World Bank.
- World Bank. 2019. *Africa's Pulse: An Analysis of Issues Shaping Africa's Economic Future*. Vol. 19 (April). Washington, DC: World Bank.

Annex

Tables

Table 1. Descriptive Statistics

Variable		Benin	Côte d'Ivoire	Guinea-Bissau	Mali	Niger	Senegal	Togo	Pooled
Log Per capita total expenditure	min	10.12	10.61	11.12	10.60	10.60	11.07	10.38	10.12
	max	16.18	15.91	15.55	15.40	16.16	16.48	15.71	16.48
	mean	12.70	13.06	12.63	12.73	12.38	13.02	12.74	12.80
	sd	0.61	0.63	0.55	0.60	0.61	0.62	0.68	0.67
	N	22087	33517	24890	23961	16811	36753	15083	173102
Price as a share of total consumption (averaged at the region level)	min	0.09	0.07	0.09	0.10	0.06	0.08	0.08	0.06
	max	0.22	0.21	0.19	0.41	0.23	0.19	0.32	0.41
	mean	0.15	0.13	0.15	0.22	0.15	0.13	0.17	0.15
	sd	0.04	0.03	0.03	0.09	0.05	0.03	0.08	0.05
	N	12.0	33.0	9.0	11.0	8.0	14.0	6.0	93.0
Household size*	min	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	max	26.00	31.00	54.00	59.00	34.00	56.00	31.00	59.00
	mean	5.20	4.43	8.19	7.14	5.96	8.91	4.21	5.70
	sd	2.94	2.80	5.11	3.89	3.11	5.78	2.62	3.77
	N	8012	12990	5351	6602	6024	7156	6171	52306
Urban	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.46	0.54	0.47	0.29	0.20	0.52	0.46	0.41
	sd	0.50	0.50	0.50	0.45	0.40	0.50	0.50	0.49
	N	22087	33517	24890	23961	16811	36753	15083	173102
Female	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.53	0.52	0.54	0.53	0.54	0.56	0.54	0.54
	sd	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	N	22087	33517	24890	23961	16811	36751	15081	173098
15-24	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.33	0.31	0.35	0.31	0.32	0.33	0.29	0.31
	sd	0.47	0.46	0.48	0.46	0.47	0.47	0.45	0.46
	N	22087	33517	24890	23960	16811	36746	15081	173092
25-40	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.39	0.40	0.38	0.35	0.38	0.33	0.37	0.37
	sd	0.49	0.49	0.49	0.48	0.49	0.47	0.48	0.48
	N	22087	33517	24890	23960	16811	36746	15081	173092
41+	min	0	0	0	0	0	0	0	0
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.29	0.29	0.27	0.34	0.30	0.34	0.34	0.31
	sd	0.45	0.46	0.44	0.47	0.46	0.47	0.47	0.46
	N	22087	33517	24890	23960	16811	36746	15081	173092
Less than primary education	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.52	0.51	0.44	0.67	0.74	0.56	0.32	0.57
	sd	0.50	0.50	0.50	0.47	0.44	0.50	0.47	0.50
	N	22087	33517	24890	23961	16811	36753	15082	173101
Less than tertiary but more than primary education	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.43	0.43	0.51	0.30	0.25	0.39	0.62	0.38
	sd	0.50	0.50	0.50	0.46	0.43	0.49	0.49	0.49
	N	22087	33517	24890	23961	16811	36753	15082	173101
Less than tertiary but more than primary education	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.05	0.07	0.05	0.04	0.01	0.05	0.07	0.05
	sd	0.22	0.25	0.22	0.19	0.12	0.22	0.25	0.21
	N	22087	33517	24890	23961	16811	36753	15082	173101
Agriculture	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.32	0.32	0.39	0.32	0.54	0.15	0.28	0.33
	sd	0.47	0.47	0.49	0.47	0.50	0.36	0.45	0.47
	N	22087	33517	24890	23961	16810	36725	15083	173073
Industry	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.14	0.08	0.07	0.05	0.06	0.10	0.12	0.08
	sd	0.34	0.28	0.25	0.22	0.23	0.29	0.33	0.28
	N	22087	33517	24890	23961	16810	36725	15083	173073
Services	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

	mean	0.31	0.28	0.19	0.19	0.13	0.28	0.30	0.24
	sd	0.46	0.45	0.39	0.39	0.34	0.45	0.46	0.43
	N	22087	33517	24890	23961	16810	36725	15083	173073
Unemployed	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.24	0.32	0.35	0.44	0.28	0.47	0.30	0.35
	sd	0.43	0.47	0.48	0.50	0.45	0.50	0.46	0.48
	N	22087	33517	24890	23961	16810	36725	15083	173073
Read/Write French	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.47	0.53	0.56	0.33	0.22	0.44	0.65	0.43
	sd	0.50	0.50	0.50	0.47	0.41	0.50	0.48	0.50
	N	22087	33517	24890	23961	16811	36753	15083	173102
Individual has access to internet through cell phone	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.15	0.24	0.18	0.15	0.08	0.34	0.23	0.20
	sd	0.36	0.43	0.39	0.35	0.26	0.47	0.42	0.40
	N	22087	33517	24890	23961	16811	36753	15083	173102
Individual has access to internet at home	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.00	0.02	0.00	0.01	0.01	0.02	0.01	0.01
	sd	0.07	0.14	0.05	0.10	0.08	0.15	0.08	0.11
	N	22087	33517	24890	23961	16811	36753	15083	173102
Individual has access to internet at work	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.01	0.02	0.01	0.01	0.00	0.01	0.02	0.01
	sd	0.09	0.13	0.08	0.10	0.06	0.10	0.12	0.10
	N	22087	33517	24890	23961	16811	36753	15083	173102
Individual has access to internet at cybercafe	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.01	0.03	0.00	0.00	0.00	0.00	0.02	0.01
	sd	0.08	0.17	0.04	0.05	0.03	0.05	0.13	0.10
	N	22087	33517	24890	23961	16811	36753	15083	173102
Individual has access to internet at school/university	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.00	0.01	0.00	0.00	0.00	0.01	0.01	0.00
	sd	0.05	0.08	0.04	0.05	0.03	0.07	0.12	0.07
	N	22087	33517	24890	23961	16811	36753	15083	173102
Age of cell phone*	min	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
	max	6.50	3.50	3.00	5.00	5.00	3.00	3.50	6.50
	mean	1.68	1.23	1.02	1.52	1.36	0.96	1.42	1.35
	sd	0.66	0.45	0.46	0.66	0.67	0.45	0.58	0.61
	N	8000	12978	5351	6386	6014	7156	6171	52056
Household has access to electricity*	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.26	0.49	0.19	0.21	0.12	0.60	0.38	0.34
	sd	0.44	0.50	0.39	0.41	0.33	0.49	0.49	0.47
	N	8012	12990	5351	6602	6024	7156	6171	52306
Household owns a television*	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.23	0.45	0.26	0.37	0.10	0.58	0.36	0.34
	sd	0.42	0.50	0.44	0.48	0.31	0.49	0.48	0.47
	N	8012	12990	5351	6602	6024	7156	6171	52306
Household owns a computer*	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.03	0.05	0.08	0.04	0.02	0.11	0.05	0.05
	sd	0.17	0.22	0.28	0.18	0.13	0.31	0.23	0.21
	N	8012	12990	5351	6602	6024	7156	6171	52306
Household owns a tablet*	min	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	max	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	mean	0.01	0.02	0.05	0.01	0.01	0.06	0.01	0.02
	sd	0.08	0.14	0.21	0.12	0.08	0.23	0.12	0.13
	N	8012	12990	5351	6602	6024	7156	6171	52306

Source: Elaboration based on EHCVM 2018–19 for each country.

(*)-Household level variables

Table 2. Determinants of Adoption Probit Results

	(1) Benin	(2) Cote D'Ivoire	(3) Guinea-Bissau	(4) Mali	(5) Niger	(6) Senegal	(7) Togo	(8) Pooled Sample
Log Per capita total expenditure	0.550*** (0.040)	0.602*** (0.033)	0.466*** (0.043)	0.653*** (0.046)	0.607*** (0.056)	0.530*** (0.034)	0.494*** (0.049)	0.554*** (0.016)
Price	-1.980*** (0.504)	-2.158*** (0.521)	-3.605*** (0.724)	-3.676*** (0.519)	-2.073*** (0.640)	-2.246*** (0.656)	-1.626*** (0.362)	-2.800*** (0.222)
Household size	0.012** (0.006)	0.037*** (0.006)	0.008** (0.003)	0.020*** (0.005)	0.020*** (0.008)	0.012*** (0.002)	0.023** (0.010)	0.019*** (0.002)
Urban=1	0.264*** (0.046)	0.327*** (0.048)	0.410*** (0.063)	0.323*** (0.067)	0.376*** (0.082)	0.149*** (0.044)	0.447*** (0.058)	0.270*** (0.024)
Female=1	-0.607*** (0.032)	-0.403*** (0.031)	-0.329*** (0.032)	-0.394*** (0.043)	-0.402*** (0.052)	-0.215*** (0.023)	-0.292*** (0.041)	-0.364*** (0.014)
15-24=1	0.059 (0.048)	0.423*** (0.045)	0.459*** (0.041)	0.384*** (0.056)	0.318*** (0.029)	0.568*** (0.029)	0.016 (0.061)	0.370*** (0.020)
25-40=1	0.462*** (0.041)	0.584*** (0.041)	0.567*** (0.038)	0.615*** (0.052)	0.566*** (0.064)	0.762*** (0.028)	0.323*** (0.050)	0.586*** (0.018)
Primary and secondary=1	0.228*** (0.064)	0.023 (0.044)	0.091* (0.051)	-0.076 (0.070)	0.295*** (0.098)	0.024 (0.038)	0.039 (0.091)	0.035 (0.025)
Tertiary=1	1.139*** (0.090)	0.644*** (0.064)	0.601*** (0.075)	0.566*** (0.109)	1.126*** (0.157)	0.571*** (0.068)	0.793*** (0.133)	0.741*** (0.038)
Agriculture=1	-0.343*** (0.071)	-0.261*** (0.045)	-0.202*** (0.045)	-0.174*** (0.066)	-0.012 (0.077)	-0.042 (0.043)	-0.253*** (0.071)	-0.196*** (0.024)
Industry=1	0.034 (0.053)	0.175*** (0.054)	0.052 (0.055)	0.047 (0.075)	-0.027 (0.088)	0.339*** (0.040)	0.280*** (0.074)	0.167*** (0.025)
Services=1	0.296*** (0.047)	0.229*** (0.034)	0.218*** (0.038)	0.260*** (0.055)	0.395*** (0.065)	0.301*** (0.028)	0.421*** (0.053)	0.285*** (0.017)
Read/Write french=1	0.898*** (0.073)	1.262*** (0.054)	0.474*** (0.051)	1.331*** (0.084)	0.322*** (0.087)	0.451*** (0.035)	0.848*** (0.099)	0.842*** (0.027)
Internet access at home=1	0.332 (0.271)	0.463** (0.213)	0.295 (0.379)	1.191*** (0.308)	0.527** (0.262)	0.550*** (0.157)	0.725 (0.603)	0.579*** (0.113)
Internet access at work=1	0.714*** (0.238)	0.402*** (0.129)	0.539*** (0.183)	0.974*** (0.230)	0.546* (0.280)	0.630*** (0.154)	1.411*** (0.215)	0.639*** (0.082)
Internet access at cyber cafe=1	0.154 (0.162)	0.230** (0.104)	0.211 (0.300)	0.572 (0.350)	0.489 (0.828)	-0.618*** (0.211)	0.449*** (0.170)	0.304*** (0.080)
Internet access at school/university=1	0.730*** (0.269)	0.590*** (0.220)	0.770** (0.376)	0.158 (0.316)	1.109** (0.456)	-0.032 (0.131)	1.247*** (0.227)	0.508*** (0.100)
Median age cell (grappe)	-0.041 (0.107)	-0.329 (0.237)	-0.112 (0.210)	0.146 (0.235)	0.310 (0.246)	0.279* (0.163)	0.508*** (0.196)	0.122 (0.076)
Median age cell (grappe) # Median age cell (grappe)	-0.009 (0.027)	0.081 (0.081)	0.039 (0.083)	-0.051 (0.065)	-0.124 (0.086)	-0.155** (0.066)	-0.138** (0.061)	-0.054** (0.023)
Household has access to electricity=1	0.360*** (0.043)	0.152*** (0.042)	0.086 (0.054)	0.076 (0.060)	0.088 (0.081)	0.227*** (0.048)	0.285*** (0.055)	0.196*** (0.022)
Household owns a television=1	0.248*** (0.046)	0.165*** (0.036)	0.205*** (0.047)	0.237*** (0.055)	0.448*** (0.074)	0.329*** (0.043)	0.400*** (0.052)	0.269*** (0.020)
Household owns a computer=1	0.368*** (0.083)	0.185*** (0.071)	0.092 (0.056)	-0.010 (0.103)	0.217* (0.130)	0.065 (0.045)	0.023 (0.087)	0.089*** (0.032)
Household owns a tablet=1	0.044 (0.194)	0.194* (0.113)	0.311*** (0.074)	-0.074 (0.130)	0.348** (0.158)	0.054 (0.066)	0.025 (0.141)	0.076 (0.049)
Constant	-9.141*** (0.541)	-10.014*** (0.498)	-7.497*** (0.615)	-10.468*** (0.713)	-9.976*** (0.746)	-8.563*** (0.489)	-8.996*** (0.666)	-9.270*** (0.234)
Observations	22059	33479	24890	23363	16780	36718	15080	172369
Pseudo r2	0.446	0.419	0.307	0.493	0.455	0.270	0.432	0.417
Chi-squared	3154.838	3678.595	2294.085	2298.988	1926.605	2855.502	2244.371	12144.981

Note: Standard errors in parentheses clustered by enumeration area. Country fixed effects are included for the pooled sample (Column 8). 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 at which the survey is representative. This value is then computed as a share of total consumption at the same geographic level to adjust for the cost of living. This value is then imputed to each individual observed in the microdata. Age of cellphone is the median value at the EA level of time the household has owned the device. 41+ years of age is the base variable for age brackets. Less than primary education is the base variable across education categories. Base category for read/write French is national languages, other languages, and those that cannot read and write. For Guinea-Bissau the dummy refers to those that can read/write Portuguese. Base category for sector jobs is those that are unemployed or not active in labor force. Agriculture includes jobs in crop yields, fisheries and animal breeding jobs. Industry includes extractive and other industries, and public works/construction jobs. Services includes commerce, restaurants/hotels, transportation, communication, education, health, other and personal services jobs. Per capita expenditure, household size, access to electricity, owning a computer, television and tablet are household level variables. * p<0.1, ** p<0.05, *** p<0.01.

Table 3. Average Marginal Effects of Determinants of Adoption

	(1) Benin	(2) Cote D'Ivoire	(3) Guinea-Bissau	(4) Mali	(5) Niger	(6) Senegal	(7) Togo	(8) Pooled Sample
Log Per capita total expenditure	0.048*** (0.004)	0.073*** (0.004)	0.050*** (0.005)	0.051*** (0.004)	0.035*** (0.004)	0.090*** (0.006)	0.062*** (0.006)	0.065*** (0.002)
Price	-0.014*** (0.003)	-0.021*** (0.003)	-0.034*** (0.007)	-0.023*** (0.003)	-0.009*** (0.002)	-0.032*** (0.009)	-0.015*** (0.003)	-0.024*** (0.002)
Household size	0.005** (0.002)	0.019*** (0.003)	0.008** (0.003)	0.009*** (0.002)	0.005** (0.002)	0.019*** (0.004)	0.010** (0.005)	0.012*** (0.001)
Urban=1	0.034*** (0.006)	0.060*** (0.009)	0.076*** (0.012)	0.040*** (0.008)	0.033*** (0.008)	0.040*** (0.012)	0.080*** (0.010)	0.045*** (0.004)
Female=1	-0.080*** (0.004)	-0.073*** (0.006)	-0.061*** (0.006)	-0.047*** (0.005)	-0.032*** (0.004)	-0.057*** (0.006)	-0.051*** (0.007)	-0.060*** (0.002)
15-24=1	0.008 (0.006)	0.077*** (0.008)	0.086*** (0.008)	0.046*** (0.007)	0.026*** (0.007)	0.151*** (0.007)	0.003 (0.011)	0.061*** (0.003)
25-40=1	0.063*** (0.006)	0.109*** (0.008)	0.109*** (0.007)	0.077*** (0.007)	0.048*** (0.006)	0.209*** (0.007)	0.057*** (0.009)	0.099*** (0.003)
Primary and secondary=1	0.029*** (0.008)	0.004 (0.008)	0.016* (0.009)	-0.009 (0.008)	0.024*** (0.008)	0.006 (0.010)	0.007 (0.015)	0.006 (0.004)
Tertiary=1	0.207*** (0.020)	0.131*** (0.014)	0.131*** (0.014)	0.079*** (0.018)	0.154*** (0.031)	0.163*** (0.020)	0.161*** (0.030)	0.144*** (0.009)
Agriculture=1	-0.042*** (0.008)	-0.047*** (0.008)	-0.037*** (0.008)	-0.020*** (0.008)	-0.001 (0.006)	-0.011 (0.011)	-0.042*** (0.012)	-0.031*** (0.004)
Industry=1	0.004 (0.007)	0.032*** (0.010)	0.010 (0.010)	0.006 (0.009)	-0.002 (0.007)	0.093*** (0.011)	0.050*** (0.014)	0.028*** (0.004)
Services=1	0.040*** (0.006)	0.043*** (0.006)	0.042*** (0.006)	0.032*** (0.007)	0.036*** (0.007)	0.082*** (0.008)	0.076*** (0.010)	0.048*** (0.003)
Read/Write french=1	0.112*** (0.009)	0.232*** (0.009)	0.084*** (0.009)	0.186*** (0.012)	0.027*** (0.008)	0.127*** (0.010)	0.135*** (0.014)	0.146*** (0.005)
Internet access at home=1	0.048 (0.042)	0.090** (0.044)	0.059 (0.082)	0.188*** (0.061)	0.053 (0.033)	0.155*** (0.046)	0.141 (0.129)	0.107*** (0.023)
Internet access at work=1	0.113** (0.044)	0.078*** (0.026)	0.115*** (0.042)	0.146*** (0.042)	0.056 (0.036)	0.177*** (0.045)	0.296*** (0.051)	0.119*** (0.017)
Internet access at cyber cafe=1	0.021 (0.023)	0.043** (0.020)	0.041 (0.062)	0.078 (0.054)	0.049 (0.102)	-0.144*** (0.042)	0.084** (0.034)	0.053*** (0.015)
Internet access at school/university=1	0.116** (0.050)	0.116** (0.046)	0.172* (0.097)	0.019 (0.040)	0.148 (0.092)	-0.008 (0.034)	0.260*** (0.053)	0.092*** (0.020)
Median age cell (grappe)	-0.009** (0.005)	-0.027** (0.013)	-0.008 (0.013)	0.001 (0.008)	0.001 (0.006)	-0.000 (0.015)	0.024*** (0.008)	-0.001 (0.004)
Household has access to electricity=1	0.050*** (0.006)	0.028*** (0.008)	0.016 (0.010)	0.009 (0.007)	0.007 (0.007)	0.061*** (0.013)	0.051*** (0.010)	0.032*** (0.004)
Household owns a television=1	0.034*** (0.007)	0.030*** (0.007)	0.039*** (0.009)	0.028*** (0.007)	0.042*** (0.008)	0.089*** (0.012)	0.073*** (0.010)	0.045*** (0.003)
Household owns a computer=1	0.054*** (0.013)	0.035** (0.014)	0.017 (0.011)	-0.001 (0.012)	0.019 (0.013)	0.017 (0.012)	0.004 (0.015)	0.015*** (0.005)
Household owns a tablet=1	0.006 (0.026)	0.036* (0.022)	0.062*** (0.016)	-0.009 (0.015)	0.032* (0.017)	0.014 (0.018)	0.004 (0.024)	0.012 (0.008)
Observations	22059	33479	24890	23363	16780	36718	15080	172369

Note: Standard errors in parentheses clustered by enumeration area. Average marginal effects. For log per capita expenditure and household size, marginal effects are calculated based a one unit increase in standard deviation by country. For price, marginal effects are calculated based a one unit increase in standard deviation derived from the entire sample. Country fixed effects are included for the pooled sample (Column 8). 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 at which the survey is representative. This value is then computed as a share of total consumption at the same geographic level to adjust for the cost of living. This value is then imputed to each individual observed in the microdata. Age of cellphone is the median value at the EA level of time the household has owned the device. 41+ years of age is the base variable for age brackets. Less than primary education is the base variable across education categories. Base category for read/write French is national languages, other languages, and those that cannot read and write. For Guinea-Bissau the dummy refers to those that can read/write Portuguese. Base category for sector jobs is those that are unemployed or not active in labor force. Agriculture includes jobs in crop yields, fisheries and animal breeding jobs. Industry includes extractive and other industries, and public works/construction jobs. Services includes commerce, restaurants/hotels, transportation, communication, education, health, other and personal services jobs. Per capita expenditure, household size, access to electricity, owning a computer, television and tablet are household level variables. * p<0.1, ** p<0.05, *** p<0.01.

Table 4. Heckman Corrected Probit

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Benin	Cote D'Ivoire	Guinea-Bissau	Mali	Niger	Senegal	Togo	Pooled Sample
Log Per capita total expenditure	0.590*** (0.047)	0.616*** (0.052)	0.492*** (0.051)	0.639*** (0.057)	0.554*** (0.073)	0.586*** (0.044)	0.507*** (0.059)	0.556*** (0.021)
Price	-2.708*** (0.952)	-1.891** (0.839)	-1.654** (0.775)	-3.122*** (0.611)	-0.204 (0.867)	-1.722* (0.436)	-1.693*** (0.302)	-2.098*** (0.302)
Household size	0.015* (0.008)	0.044*** (0.009)	0.010** (0.005)	0.024*** (0.006)	0.021* (0.011)	0.013*** (0.003)	0.039*** (0.013)	0.020*** (0.002)
Urban=1	0.348*** (0.080)	0.275** (0.115)	0.141 (0.112)	0.241*** (0.078)	-0.188 (0.155)	0.002 (0.079)	-0.039 (0.077)	0.114** (0.046)
Female=1	-0.561*** (0.037)	-0.321*** (0.039)	-0.246*** (0.035)	-0.373*** (0.049)	-0.253*** (0.071)	-0.180*** (0.028)	-0.274*** (0.049)	-0.299*** (0.017)
15-24=1	0.004 (0.057)	0.393*** (0.058)	0.434*** (0.051)	0.358*** (0.069)	0.460*** (0.120)	0.583*** (0.034)	-0.016 (0.070)	0.361*** (0.024)
25-40=1	0.448*** (0.047)	0.562*** (0.052)	0.543*** (0.044)	0.628*** (0.065)	0.691*** (0.080)	0.794*** (0.031)	0.360*** (0.058)	0.599*** (0.021)
Primary and secondary=1	0.359*** (0.076)	0.074 (0.066)	0.072 (0.065)	-0.003 (0.074)	0.100 (0.124)	0.062 (0.044)	0.072 (0.101)	0.064** (0.030)
Tertiary=1	1.271*** (0.102)	0.695*** (0.084)	0.572*** (0.085)	0.585*** (0.117)	0.956*** (0.182)	0.583*** (0.075)	0.760*** (0.143)	0.745*** (0.044)
Industry=1	0.141** (0.060)	0.146** (0.070)	0.034 (0.064)	-0.056 (0.083)	0.163* (0.095)	0.337*** (0.045)	0.264*** (0.085)	0.169*** (0.029)
Services=1	0.352*** (0.053)	0.223*** (0.045)	0.188*** (0.044)	0.149** (0.061)	0.397*** (0.090)	0.291*** (0.032)	0.365*** (0.057)	0.261*** (0.020)
Read/Write french=1	0.810*** (0.076)	1.336*** (0.085)	0.462*** (0.067)	1.346*** (0.086)	0.418*** (0.112)	0.434*** (0.041)	0.777*** (0.112)	0.805*** (0.034)
Internet access at home=1	-0.219 (0.271)	0.044 (0.243)	0.300 (0.372)	1.086*** (0.307)	1.569*** (0.519)	0.524*** (0.169)	0.282 (0.574)	0.470*** (0.125)
Internet access at work=1	0.666*** (0.249)	0.484*** (0.134)	0.553*** (0.179)	1.099*** (0.240)	0.764*** (0.262)	0.664*** (0.173)	1.415*** (0.215)	0.724*** (0.083)
Internet access at cyber cafe=1	0.093 (0.187)	0.163 (0.116)	0.185 (0.298)	0.604* (0.366)	-0.242 (0.540)	-0.732*** (0.201)	0.418** (0.172)	0.236** (0.094)
Internet access at school/university=1	0.956*** (0.275)	0.364 (0.288)	0.756* (0.394)	0.220 (0.344)	0.700* (0.372)	-0.001 (0.154)	1.309*** (0.238)	0.465*** (0.112)
Median age cell (grappe) # Median age cell (grappe)	0.013 (0.066)	0.436*** (0.124)	0.017 (0.082)	-0.161** (0.066)	-0.216 (0.221)	-0.102 (0.085)	-0.166** (0.075)	-0.058* (0.031)
Household has access to electricity=1	0.329*** (0.051)	0.130* (0.070)	0.088 (0.060)	-0.048 (0.063)	0.051 (0.091)	0.122** (0.062)	0.256*** (0.061)	0.127*** (0.027)
Household owns a television=1	0.266*** (0.061)	0.086 (0.054)	0.174*** (0.053)	0.209*** (0.074)	0.435*** (0.087)	0.310*** (0.053)	0.315*** (0.056)	0.245*** (0.025)
Household owns a computer=1	0.324*** (0.088)	0.066 (0.086)	0.078 (0.060)	-0.016 (0.102)	0.263** (0.127)	0.058 (0.049)	0.021 (0.090)	0.058* (0.035)
Household owns a tablet=1	0.018 (0.192)	0.217 (0.147)	0.264*** (0.083)	-0.092 (0.138)	0.194 (0.167)	0.092 (0.078)	0.005 (0.154)	0.090* (0.054)
Constant	-9.739*** (0.646)	-9.697*** (0.778)	-7.788*** (0.735)	-10.486*** (0.816)	-9.248*** (1.135)	-9.117*** (0.627)	-8.713*** (0.789)	-9.199*** (0.306)
athrho	0.184 (0.149)	-0.195** (0.082)	-0.183* (0.105)	-0.178** (0.090)	-0.425*** (0.115)	-0.197 (0.120)	-0.312*** (0.090)	-0.161*** (0.044)
Observations	22059	29914	24339	22989	16321	35209	14949	165780
Rho	0.182	-0.193	-0.181	-0.176	-0.401	-0.194	-0.302	-0.159
Chi-squared	1800.874	1231.062	910.451	1476.377	810.998	1598.684	1075.006	4865.245

Note: Standard errors in parentheses clustered by enumeration area. Country fixed effects are included for the pooled sample (Column 8). 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 at which the survey is representative. This value is then computed as a share of total consumption at the same geographic level to adjust for the cost of living. This value is then imputed to each individual observed in the microdata. This value is then imputed to each individual observed in the microdata. Age of cellphone is the median value at the EA level of time the household has owned the device. 41+ years of age is the base variable for age brackets. Less than primary education is the base variable across education categories. Base category for read/write French is national languages, other languages, and those that cannot read and write. For Guinea-Bissau the dummy refers to those that can read/write Portuguese. Base category for sector jobs is those that are unemployed or not active in labor force. Agriculture includes jobs in crop yields, fisheries and animal breeding jobs. Industry includes extractive and other industries, and public works/construction jobs. Services includes commerce, restaurants/hotels, transportation, communication, education, health, other and personal services jobs. Per capita expenditure, household size, access to electricity, owning a computer, television and tablet are household level variables. * p<0.1, ** p<0.05, *** p<0.01.

Table 5. OLS, Probit, Truncated Sample, and Heckman Corrected Probit, Senegal

	(1) OLS	(2) Probit	(3) Truncated	(4) Heckman
Log Per capita total expenditure	0.142*** (0.009)	0.530*** (0.034)	0.543*** (0.037)	0.544*** (0.037)
Price	-0.725*** (0.171)	-2.246*** (0.656)	-2.138*** (0.692)	-2.439*** (0.763)
Household size	0.003*** (0.001)	0.012*** (0.002)	0.012*** (0.002)	0.012*** (0.002)
Urban=1	0.049*** (0.013)	0.149*** (0.044)	0.144*** (0.045)	0.147*** (0.045)
Female=1	-0.058*** (0.006)	-0.215*** (0.023)	-0.215*** (0.024)	-0.215*** (0.024)
15-24=1	0.131*** (0.008)	0.568*** (0.029)	0.567*** (0.030)	0.568*** (0.030)
25-40=1	0.197*** (0.008)	0.762*** (0.028)	0.759*** (0.029)	0.759*** (0.029)
Primary and secondary=1	0.009 (0.012)	0.024 (0.038)	0.024 (0.039)	0.024 (0.039)
Tertiary=1	0.170*** (0.018)	0.571*** (0.068)	0.569*** (0.071)	0.567*** (0.071)
Agriculture=1	-0.003 (0.009)	-0.042 (0.043)	-0.041 (0.046)	-0.044 (0.046)
Industry=1	0.093*** (0.013)	0.339*** (0.040)	0.340*** (0.041)	0.341*** (0.041)
Services=1	0.080*** (0.008)	0.301*** (0.028)	0.297*** (0.029)	0.299*** (0.029)
Read/Write french=1	0.145*** (0.011)	0.451*** (0.035)	0.444*** (0.036)	0.444*** (0.036)
Internet access at home=1	0.150*** (0.036)	0.550*** (0.157)	0.592*** (0.167)	0.588*** (0.167)
Internet access at work=1	0.101*** (0.027)	0.630*** (0.154)	0.664*** (0.169)	0.662*** (0.169)
Internet access at cyber cafe=1	-0.187*** (0.066)	-0.618*** (0.211)	-0.576*** (0.216)	-0.569*** (0.217)
Internet access at school/university=1	0.005 (0.039)	-0.032 (0.131)	-0.057 (0.137)	-0.056 (0.137)
Median age cell (grappe)	0.036 (0.036)	0.279* (0.163)	0.327** (0.167)	0.320* (0.167)
Median age cell (grappe) # Median age cell (grappe)	-0.021* (0.013)	-0.155** (0.066)	-0.176** (0.069)	-0.176** (0.069)
Household has access to electricity=1	0.056*** (0.013)	0.227*** (0.048)	0.196*** (0.050)	0.204*** (0.050)
Household owns a television=1	0.081*** (0.012)	0.329*** (0.043)	0.331*** (0.045)	0.333*** (0.045)
Household owns a computer=1	0.036** (0.014)	0.065 (0.045)	0.069 (0.047)	0.066 (0.047)
Household owns a tablet=1	0.019 (0.019)	0.054 (0.066)	0.042 (0.069)	0.044 (0.069)
Constant	-1.783*** (0.131)	-8.563*** (0.489)	-8.716*** (0.524)	-8.718*** (0.524)
athrho				0.152 (0.184)
Observations	36718	36718	32515	35209
Pseudo r2		0.270	0.257	
Rho				0.151
Chi-squared		2855.502	2507.523	2443.778
R2	0.301			

Note: Standard errors in parentheses clustered by enumeration area. Country fixed effects are included for the pooled sample (Column 8). 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 at which the survey is representative. This value is then computed as a share of total consumption at the same geographic level to adjust for the cost of living. This value is then imputed to each individual observed in the microdata. Age of cellphone is the median value at the EA level of time the household has owned the device. 41+ years of age is the base variable for age brackets. Less than primary education is the base variable across education categories. Base category for read/write French is national languages, other languages, and those that cannot read and write. Base category for sector jobs is those that are unemployed or not active in labor force. Agriculture includes jobs in crop yields, fisheries and animal breeding jobs. Industry includes extractive and other industries, and public works/construction jobs. Services includes commerce, restaurants/hotels, transportation, communication, education, health, other and personal services jobs. Per capita expenditure, household size, access to electricity, owning a computer, television and tablet are household level variables. * p<0.1, ** p<0.05, *** p<0.01.

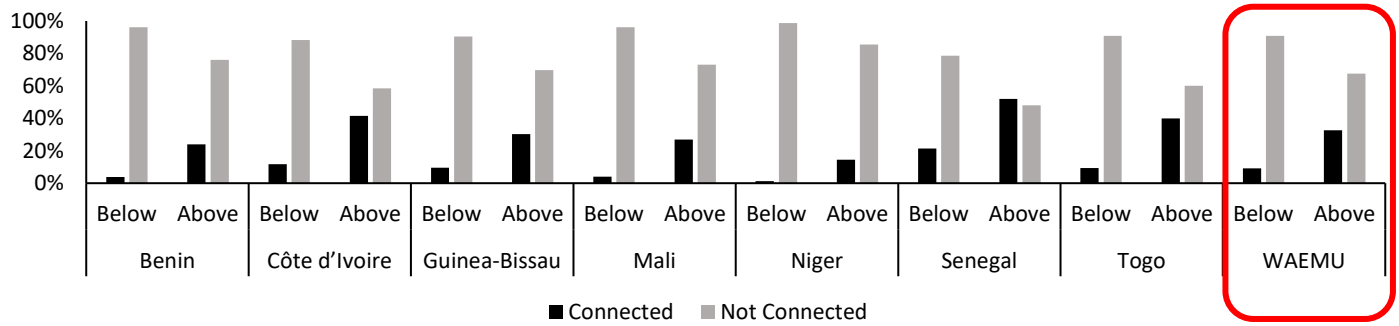
Table 6. Main Specification, by WAEMU Country and Pooled Sample, with ITU Price Data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Benin	Cote D'Ivoire	Guinea-Bissau	Mali	Niger	Senegal	Togo	Pooled Sample
Log Per capita total expenditure	0.549*** (0.040)	0.595*** (0.033)	0.466*** (0.043)	0.642*** (0.047)	0.596*** (0.056)	0.530*** (0.035)	0.495*** (0.049)	0.550*** (0.016)
ITU price basket	-3.615*** (1.093)	-3.266*** (0.821)	-1.518*** (0.336)	-5.719*** (0.756)	-2.069*** (0.761)	-3.737*** (1.355)	-3.746*** (0.659)	-3.638*** (0.302)
Household size	0.012** (0.006)	0.037*** (0.006)	0.009** (0.004)	0.020*** (0.005)	0.020** (0.008)	0.012*** (0.002)	0.024** (0.010)	0.019*** (0.002)
Urban=1	0.262*** (0.047)	0.325*** (0.049)	0.414*** (0.060)	0.313*** (0.070)	0.367*** (0.086)	0.137*** (0.045)	0.388*** (0.060)	0.264*** (0.025)
Female=1	-0.606*** (0.032)	-0.404*** (0.031)	-0.326*** (0.032)	-0.389*** (0.043)	-0.400*** (0.053)	-0.213*** (0.023)	-0.293*** (0.041)	-0.362*** (0.014)
15-24=1	0.059 (0.048)	0.424*** (0.046)	0.454*** (0.041)	0.392*** (0.056)	0.314*** (0.081)	0.571*** (0.029)	0.022 (0.061)	0.371*** (0.020)
25-40=1	0.463*** (0.041)	0.583*** (0.042)	0.567*** (0.037)	0.617*** (0.052)	0.561*** (0.063)	0.763*** (0.028)	0.327*** (0.050)	0.584*** (0.018)
Primary and secondary=1	0.227*** (0.064)	0.025 (0.044)	0.094* (0.051)	-0.063 (0.070)	0.300*** (0.096)	0.019 (0.037)	0.038 (0.090)	0.040 (0.025)
Tertiary=1	1.141*** (0.090)	0.645*** (0.064)	0.603*** (0.075)	0.574*** (0.110)	1.130*** (0.153)	0.567*** (0.068)	0.788*** (0.133)	0.746*** (0.038)
Agriculture=1	-0.343*** (0.071)	-0.256*** (0.045)	-0.203*** (0.045)	-0.138** (0.065)	-0.010 (0.079)	-0.047 (0.043)	-0.226*** (0.071)	-0.183*** (0.024)
Industry=1	0.033 (0.053)	0.174*** (0.053)	0.048 (0.054)	0.060 (0.076)	-0.036 (0.088)	0.345*** (0.041)	0.282*** (0.075)	0.172*** (0.025)
Services=1	0.294*** (0.047)	0.228*** (0.034)	0.216*** (0.037)	0.265*** (0.055)	0.392*** (0.066)	0.307*** (0.028)	0.424*** (0.052)	0.289*** (0.017)
Read/Write french=1	0.899*** (0.074)	1.260*** (0.054)	0.481*** (0.051)	1.324*** (0.085)	0.320*** (0.085)	0.449*** (0.035)	0.850*** (0.098)	0.839*** (0.027)
Internet access at home=1	0.349 (0.272)	0.463** (0.212)	0.303 (0.379)	1.191*** (0.311)	0.536** (0.261)	0.548*** (0.157)	0.734 (0.601)	0.581*** (0.113)
Internet access at work=1	0.719*** (0.238)	0.396*** (0.129)	0.540*** (0.182)	0.985*** (0.229)	0.546** (0.278)	0.624*** (0.154)	1.411*** (0.217)	0.634*** (0.082)
Internet access at cyber cafe=1	0.120 (0.157)	0.229** (0.104)	0.207 (0.300)	0.556 (0.346)	0.452 (0.830)	-0.613*** (0.211)	0.439*** (0.170)	0.304*** (0.081)
Internet access at school/university=1	0.731*** (0.268)	0.598*** (0.221)	0.772** (0.375)	1.140 (0.315)	1.093** (0.451)	-0.031 (0.132)	1.244*** (0.227)	0.510*** (0.100)
Median age cell (grappe)	-0.055 (0.106)	-0.329 (0.237)	-0.118 (0.208)	0.119 (0.244)	0.369 (0.252)	0.300* (0.164)	0.561*** (0.199)	0.131* (0.077)
Median age cell (grappe) # Median age cell (grappe)	-0.008 (0.027)	0.081 (0.081)	0.038 (0.081)	-0.047 (0.068)	-0.144 (0.090)	-0.165** (0.066)	-0.150** (0.062)	-0.058** (0.023)
Household has access to electricity=1	0.365*** (0.043)	0.148*** (0.041)	0.084 (0.055)	0.062 (0.060)	0.098 (0.082)	0.237*** (0.048)	0.269*** (0.055)	0.201*** (0.022)
Household owns a television=1	0.251*** (0.046)	0.157*** (0.036)	0.202*** (0.046)	0.247*** (0.056)	0.447*** (0.075)	0.335*** (0.043)	0.399*** (0.052)	0.270*** (0.020)
Household owns a computer=1	0.374*** (0.083)	0.185*** (0.071)	0.087 (0.056)	-0.008 (0.104)	0.235* (0.132)	0.065 (0.045)	0.014 (0.086)	0.094*** (0.032)
Household owns a tablet=1	0.036 (0.195)	0.191* (0.112)	0.313*** (0.074)	-0.077 (0.131)	0.351** (0.156)	0.055 (0.066)	0.009 (0.140)	0.072 (0.048)
Constant	-9.051*** (0.545)	-9.876*** (0.508)	-7.469*** (0.613)	-10.108*** (0.732)	-9.849*** (0.755)	-8.647*** (0.491)	-8.716*** (0.662)	-9.270*** (0.233)
Observations	22059	33479	24890	23363	16780	36718	15080	172369
Pseudo r2	0.446	0.419	0.306	0.493	0.455	0.270	0.433	0.416
Chi-squared	3148.091	3704.584	2219.662	2230.534	1934.407	2882.349	2209.515	12292.816

Note: Standard errors in parentheses clustered by enumeration area. Country fixed effects are included for the pooled sample (Column 8). Price is obtained by computing ITU's data-only mobile broadband price basket as a share of total consumption at each country's geographic area for which the survey is representative. This value is then imputed to each individual observed in the microdata. The data-only mobile broadband price basket is based on a minimum monthly allowance of at least 1.5 GB of data. Age of cellphone is the median value at the EA level of time the household has owned the device. 41+ years of age is the base variable for age brackets. Less than primary education is the base variable across education categories. Base category for read/write French is national languages, other languages, and those that cannot read and write. For Guinea-Bissau the dummy refers to those that can read/write Portuguese. Base category for sector jobs is those that are unemployed or not active in labor force. Agriculture includes jobs in crop yields, fisheries and animal breeding jobs. Industry includes extractive and other industries, and public works/construction jobs. Services includes commerce, restaurants/hotels, transportation, communication, education, health, other and personal services jobs. Per capita expenditure, household size, access to electricity, owning a computer, television and tablet are household level variables. * p<0.1, ** p<0.05, *** p<0.01.

Figures

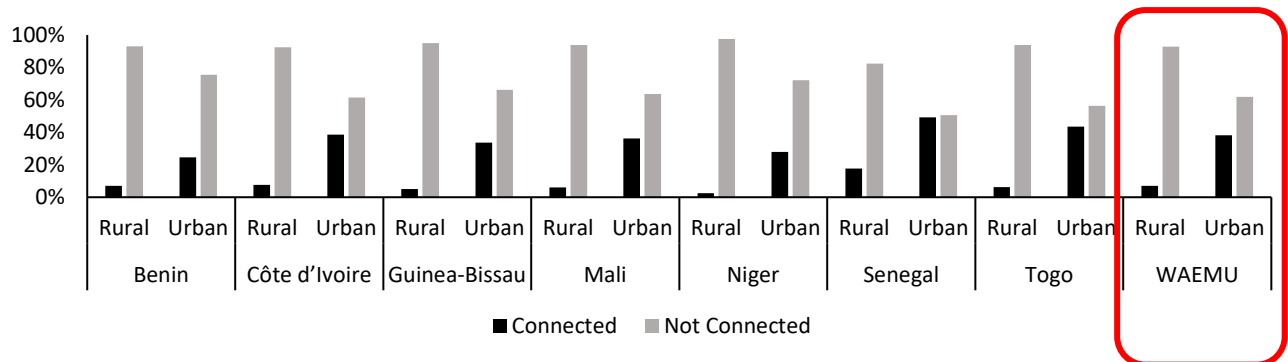
Figure 1. Share of Connected and Nonconnected Individuals, by Median Consumption Threshold



Source: Elaboration based on EHCVM 2018-19 for each country.

Note: Median consumption is defined as household consumption per capita. Individuals ages 15+.

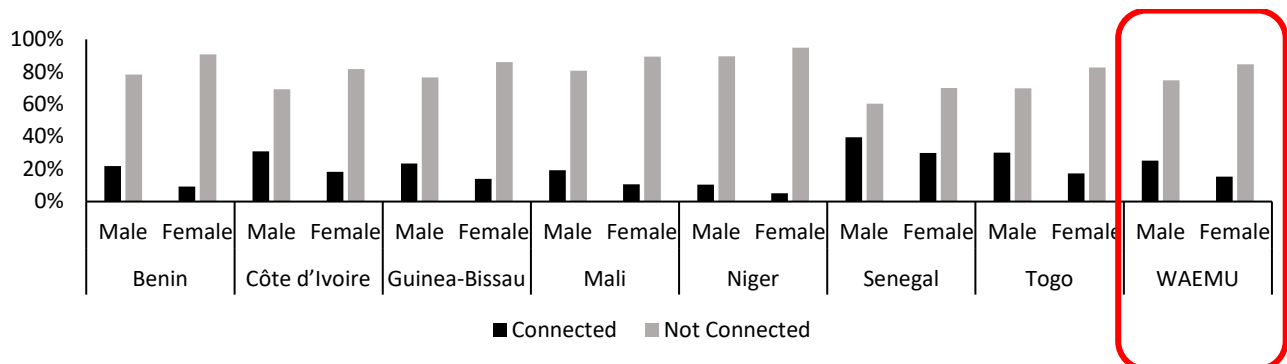
Figure 2. Share of Connected and Nonconnected Individuals, by Urban and Rural Location



Source: Elaboration based on EHCVM 2018-19 for each country.

Note: Individuals ages 15+.

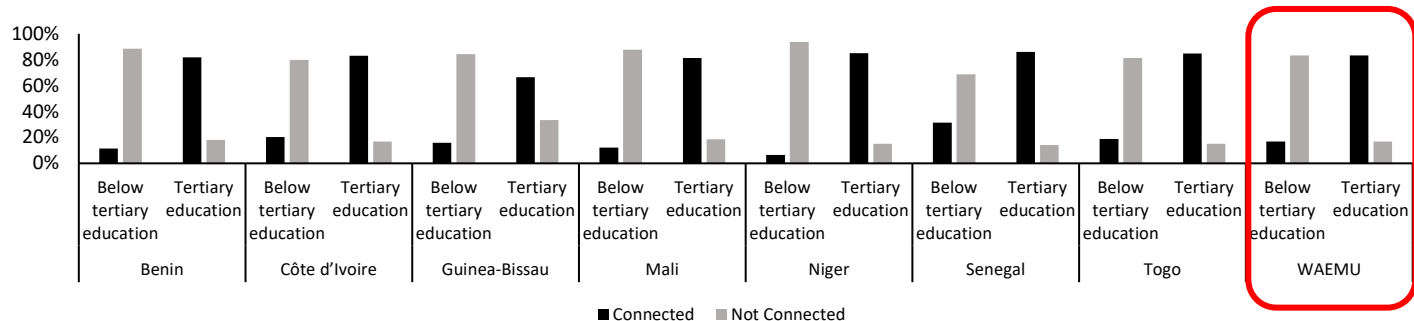
Figure 3. Share of Connected and Nonconnected Individuals, by Sex



Source: Elaboration based on EHCVM 2018-19 for each country.

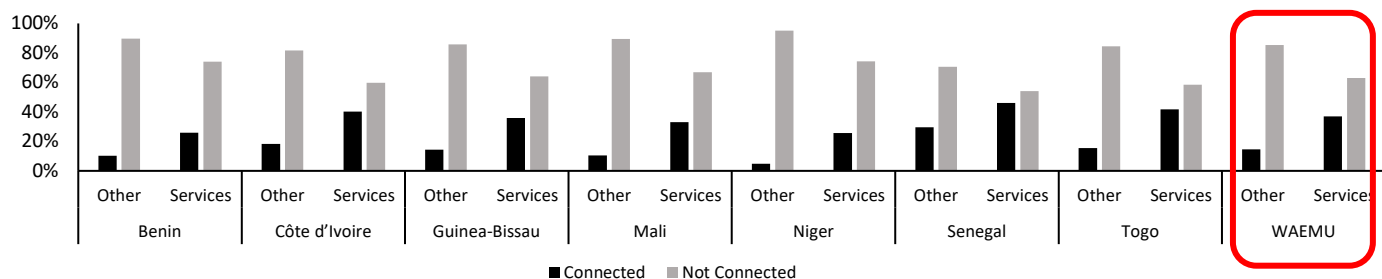
Note: Individuals ages 15+.

Figure 4. Share of Connected and Nonconnected Individuals, by Tertiary Education



Source: Elaboration based on EHCVM 2018-19 for each country.
 Note: Individuals ages 15+.

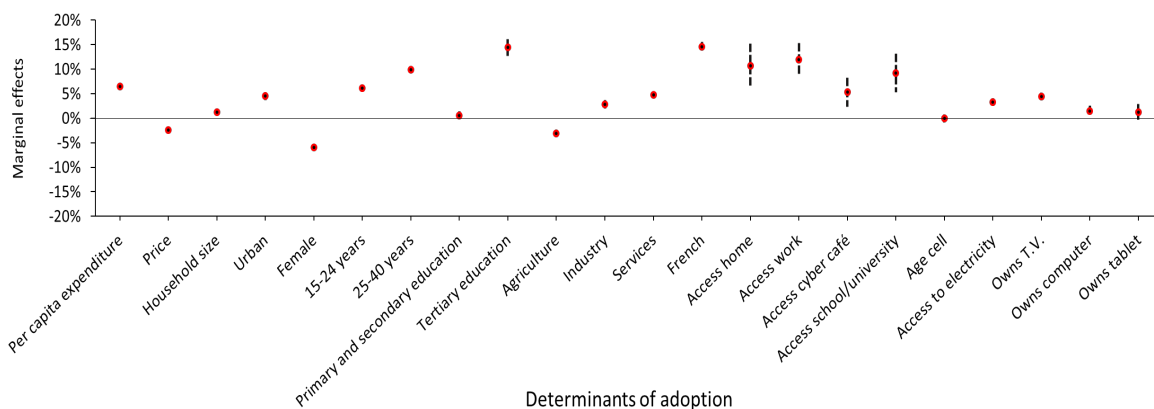
Figure 5. Share of Connected and Nonconnected Individuals, by Service Sector



Source: Elaboration based on EHCVM 2018-19 for each country.

Note: Individuals ages 15+. Services include commerce, restaurants and hotels, transportation, communication, education, health care, other, and personal services jobs.

Figure 6. Determinants of Adoption: Average Marginal Effects, Pooled Sample



Note: Point estimates with 95 percent confidence intervals. Average marginal effects. Marginal effects for log per capita expenditure, price and household size are calculated based on a one unit increase in standard deviation, equivalent, respectively, to CFAF 36,400 (US\$65) per capita per month, CFAF 2,000 (US\$3.60) per month and about four household members. The binary dependent variable is mobile internet access, which refers to individuals who access the internet through their mobile telephone devices. 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 at which the survey is representative. This value is then computed as a share of total consumption at the same geographic level to adjust for cost of living. This value is then 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. Secondary education is defined as individuals with less than tertiary but more 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 that cannot read and write. Age of cell phone is the median value of time that the household has owned the device at the enumeration area level. The base variable across labor market sectors refers to inactive and unemployed. The agriculture sector includes jobs in crop yields, fisheries and animal breeding. The industry sector includes extractive and other industries, and public works/construction jobs. The services sector includes commerce, restaurants/hotels, transportation, communication, education, health, other and personal services jobs. Per capita expenditure, household size, access to electricity, owning a computer, tablet and television are household-level variables. All results are statistically significant, with the exception of primary and secondary education, median age of cellphone, and for households that own a tablet.