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Digitalization in MENA and Sub-Saharan Africa:

A Comparative Analysis of Mobile Internet Uptake and Use in Sub-Saharan Africa and MENA Countries

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DIGITALIZATION IN MENA AND SUB-SAHARAN AFRICA – A COMPARATIVE ANALYSIS OF MOBILE INTERNET UPTAKE AND USE IN SUB-SAHARAN AFRICA AND MENA COUNTRIES [1]

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Abstract

This paper focuses on uptake and use of mobile internet-enabled smartphones as a key access technology enabling benefits from digitalization. Geographically, the paper focuses on three regions of the African continent and the Middle East, namely sub-Saharan Africa (SSA), North Africa (NAfr) and non-rich Middle East (NRME) countries. The paper documents positive causal impacts of internet availability on the probability of employment, labor force participation, and falling poverty rates. The paper provides the following new findings. First, the main constraint to the benefits arising from broader digitalization lies not in internet coverage but in too little uptake and use of internet and the range of productive technologies that are enabled by internet. The paper finds that SSA, followed by NRME, South Asia and NAfr regions have the highest uptake gaps in the world, namely the highest percentage of their populations that have no internet use even though they are covered by at least a 3G network. Second, on the demand side, the most important conditional correlates of low uptake and use include low affordability as reflected in low incomes, high data prices and higher income inequality, low capabilities as reflected in low levels of education and skills, low levels of other complementary assets (especially electricity), and low attractiveness as reflected in low perceptions of useful content. The paper finds evidence of a significant positive correlation between lower uptake and lower incomes, lower capabilities, and lower access to electricity. Third, on the supply side, given levels of demand, the offered variety, quality, and price of internet and enabled digital services are critically associated with the level of market competition. The level of competition, in turn, depends on the policy and regulatory frameworks that govern the evolution of these markets. The paper finds evidence of a significant negative correlation between uptake and the degree of concentration in the mobile market as well as the key regulatory variable of Mobile Termination Rates (MTRs). Finally, when explored in a joint regression framework that combines selected demand and supply-side variables, quantitatively the most important variable associated with internet uptake is affordability (proxied by GDP per capita), followed by skills and electricity. Regulatory stance also matters: the statistical significance of market concentration and not MTRs suggests that regulatory actions and timing, including how they affect the nature and sequencing of entry may be more important than policies focusing on MTRs.

Keywords: mobile internet-enabled smartphones; digitalization; Sub-Saharan Africa, Middle-East and North Africa

JEL Classifications: F1, F6

ملخص

تركز هذه الورقة على اســتيعاب واســتخدام الهواتف الذكية التي تدعم الإنترنت على الهاتف المحمول كتقنية وصــول رئيســية تتيح الاســتفادة من الرقمنة. من الناحية الجغرافية ، تركز الورقة على ثلاث مناطق في القارة الأفريقية والشرـق الأوســط ، وهي إفريقيا جنوب الصــحراء الكبرى (SSA) وشــمال إفريقيا (NAfr) ودول الشرـق الأوســط غير الغنية (NRME). توثق الورقة الآثار الســببية الإيجابية لتوافر الإنترنت على احتمالية التوظيف والمشــاركة في القوى العاملة وانخفاض معدلات الفقر. تقدم الورقة النتائج الجديدة التالية. أولاً ، لا يكمن القيد الرئيسيـ للفوائد الناشـئة عن الرقمنة الأوســع في تغطية الإنترنت ولكن في قلة اســتيعاب واســتخدام الإنترنت ومجموعة التقنيات الإنتاجية التي يتم تمكينها بواســطة الإنترنت. وجدت الورقة أن منطقة جنوب الصــحراء الكبرى ، تليها مناطق NRME ، وجنوب آســيا ومنطقة NAfr بها أعلى فجوات امتصـاص في العالم ، وهي أعلى نسـبة من سـكانها الذين لا يسـتخدمون الإنترنت على الرغم من تغطيتهم بشــبكة G3 على الأقل. ثانيًا ، من ناحية الطلب ، تشــمل أهم الارتباطات المشرـوطة لانخفاض الاســتيعاب

والاســـتخدام انخفاض القدرة على تحمل التكاليف كما ينعكس في الدخل المنخفض ، وارتفاع أســـعار البيانات ، وزيادة التفاوت في الدخل ، والقدرات المنخفضـة كما ينعكس في انخفاض مسـتويات التعليم والمهارات ، وانخفاض مسـتويات أخرى. الأصول التكميلية (خاصة الكهرباء) ، وانخفاض الجاذبية كما ينعكس في التصورات المنخفضة للمحتوى المفيد. وجدت الورقة دليلاً على وجود علاقة إيجابية مهمة بين انخفاض الإقبال وانخفاض الدخل ، وانخفاض القدرات ، وانخفاض فرص الحصـــول على الكهرباء. ثالثًا ، على جانب العرض ، نظرًا لمســـتويات الطلب ، والتنوع المعروض ، والجودة ، وسعر الإنترنت والخدمات الرقمية الممكّنة ترتبط ارتباطًا وثيقًا بمستوى المنافسة في السوق. يعتمد مستوى المنافسـة بدوره على السياسات والأطر التنظيمية التي تحكم تطور هذه الأسواق. وجدت الورقة دليلًا على وجود علاقة سـلبية كبيرة بين الاسـتيعاب ودرجة التركيز في سـوق الهاتف المحمول بالإضـافة إلى المتغير التنظيمي الرئيسي لمعدلات إنهاء الخدمة المتنقلة (MTRs). أخيرًا ، عند اسـتكشـافها في إطار انحدار مشـترك يجمع بين متغيرات مختارة من جانب العرض والطلب ، فإن المتغير الأكثر أهمية من الناحية الكمية المرتبط بامتصـــاص الإنترنت هو القدرة على تحمل التكاليف (مقتبسًـا من الناتج المحلي الإجمالي للفرد) ، متبوعًا بالمهارات والكهرباء. كما أن الموقف التنظيمي مهم أيضًـا: تشـير الأهمية الإحصـائية لتركيز السـوق وليس تقارير منتصـف المدة إلى أن الإجراءات التنظيمية والتوقيت ، بما في ذلك كيفية تأثيرها على طبيعة وتسلسل الدخول قد تكون أكثر أهمية من السياسات التي تركز على تقارير منتصف المدة.

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1. Introduction

Digitalization, namely the conversion of information into digital form and the use of associated digital technologies by enterprises, households, governments, and other civil society entities, can bring a range of benefits to users. A critical prerequisite for the use of many more sophisticated digital technologies is availability and affordable uptake of internet. Increasingly, it is mobile internet that has become the main technology for most people, especially in lower-income countries, to access the benefits of digitalization.

This paper focuses on uptake and use of mobile internet using smartphones, namely internet-enabled mobile phones, as a key access technology enabling many of the benefits of digitalization.[3] Geographically, the paper focuses on three regions of the African continent and the Middle East, namely sub-Saharan Africa (SSA), North Africa (NAfr) and non-rich Middle East (NRME) countries, in contrast to rich countries in the Middle East and North Africa (RMENA). These three regions are characterized by some of the lowest per capita income levels in the world at the beginning of the decade, with average annual income levels of roughly $5,000 per person in SSA, and $12,000 in NAfr and NRME in 2010, relative to almost North American levels in RME countries.[4] The only other global region with a comparably low average per capita income level in 2010 is South Asia, at roughly $6,000 per person. However, while South Asia's regional per capita income increased by approximately 30 percent between 2010 and 2019, the highest growth of all regions, NAfr, NRME and SSA had the lowest regional growth rates of all developing countries over this period: the regional per capita income of NAfr and NRME actually declined over this period, by 15 and 5 percent, respectively, while the regional per capita income of SSA increased by only 5 percent. In terms of mobile internet coverage, SSA and NRME had the lowest average 3G coverage rates in the world in 2010, at 26 and 30 percent of the population, respectively. These two regions have continued to have the lowest average 3G coverage rates in the world by 2019, before the onset of Covid, at 69 and 90 percent of their regional population. However, these increases in coverage did not translate into significantly higher uptake and use. By 2019, these two regions also continued to have some of the lowest global rates of usage in the world, with the average unique usage of mobile internet at roughly 25 percent of the regional population in SSA, 37

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[3] In a companion paper, de Melo and Solleder (2022) examine the likely effects of digitalization on jobs for SSA and a service-sector led transformation for MENA. They warn that the complementarity between humans and machines observed in previous spells of technical progress may be threatened by the continued growth in automation and robots. They also find that an increase in telecom subscriptions is associated with increased participation in global value chains through reductions in trade costs.

[4] These figures are in PPP constant 2017 prices. The average for SSA includes all 46 countries except Eritrea and South Sudan, NAfr includes Algeria, Djibouti, Egypt, Libya, Morocco, and Tunisia, NRME includes Iran, Iraq, Jordan, Lebanon, and West Bank-Gaza (no data for Syria and Yemen) while RMENA covers Bahrain, Israel, Kuwait, Malta, Oman, Qatar, Saudi Arabia, and United Arab Emirates. "Rich" and "non-rich" are used to separate a country such as Lebanon, classified as upper-middle income in 2010, from the much wealthier RME countries. The average per capita income of RME in 2010 was $50,000, almost at the level of North America (roughly $62,000). Regional averages are unweighted means across countries (by giving equal importance to each country rather than weighting countries by their share in regional populations, heterogeneity across countries is highlighted). The composition of regions, along with per capita income and their score and rank in the network readiness index are shown in Annex 1.

percent in NRME, and 41 percent in NAfr. And while there were significant investments and increases in coverage in SSA, NRME and NAfr in 2020 after the onset of Covid, these increases in coverage were not accompanied with similar increases in uptake and use.

The paper sets the context for its inquiry by surveying the new evidence available on the impacts of digitalization on private sector development-driven productivity growth, jobs growth, and associated welfare benefits. Initial findings of positive impact highlighted that for those enterprises and households located in the vicinity of terrestrial broadband networks, the probability that an individual is employed increased by 6.9 and 13.2 percent, for countries in different samples across SSA, relative to areas unconnected to submarine cables (Hjort and Poulsen, 2019). Three subsequent country case studies – on Nigeria, Senegal, and Tanzania – have added to this growing evidence base by exploring the impact of mobile internet availability (3G or 4G coverage) – instead of fixed terrestrial broadband – on jobs and welfare. In Nigeria and Tanzania, labor force participation increased by 3 and 8 percentage points, respectively, after three or more years of exposure to internet availability relative to areas with no coverage, with poverty rates falling by 7 percentage points (Bahia et al., 2020 and 2021). 3G availability in Senegal is associated with 5 percent higher formal employment than non-covered areas (Masaki et al, 2020). Welfare results are higher among poorer and less-educated households. Robust causal evidence also exists that better access to mobile money has led to better jobs and a reduction in poverty over time. In addition, recent evidence from firm-level surveys reveals positive associations between firm level outcomes such as productivity and jobs and use of digital technologies.

The paper provides the following new findings:

- In SSA and to some extent in NAfr and NRME regions, especially in those countries where uptake is lower than regional averages, the main constraint to the benefits arising from broader digitalization lies not in internet coverage but in too little uptake and use of internet and the range of productive technologies that are enabled by internet. The paper finds that SSA, followed by NRME, South Asia and NAfr regions, have the highest uptake gaps in the world, namely the highest percentage of their populations that have no uptake and use of internet even though they are covered by at least a 3G network.
- On the demand side, the most important conditional correlates of low uptake and use include low affordability as reflected in low incomes, high data prices and higher income inequality, low capabilities as reflected in low levels of education and skills, low levels of other complementary assets (especially electricity), and low attractiveness as reflected in low perceptions of useful content. The paper finds evidence of a significant positive correlation between lower uptake and lower incomes, lower capabilities, and lower access to electricity.
- On the supply side, given levels of demand, the offered variety, quality, and price of internet and enabled digital services are critically associated with the level of market competition. The level of competition, in turn, depends critically on the policy and regulatory frameworks that govern the evolution of these markets. The paper finds evidence of a significant negative correlation between uptake and the degree of concentration in the mobile market as well as the key regulatory variable of Mobile Termination Rates (MTRs).

- When explored in a joint regression framework that combines selected demand and supply-side variables, quantitatively the most important variable associated with internet uptake is affordability (proxied by GDP per capita), followed by skills and electricity. Next is regulatory stance: market concentration remains significant while MTRs do not, plausibly suggesting that regulatory actions and timing, including how they affect the nature and sequencing of entry may be more important than policies specially focusing on MTRs.

The remainder of the paper is organized to facilitate this understanding. Section 2 provides a succinct review of the relevant literature, with a focus on what is known about the benefits of digitalization, as context for the ensuing comparative analysis. Section 3 summarizes available information on the extent of coverage and use of mobile internet through smartphones. Sections 4 and 5 explore factors affecting demand and supply of mobile internet, respectively. Section 6 provides a more detailed analysis of the evolution of mobile markets in a few case studies. Section 7 provides an assessment of the relative quantitative importance of the selected factors on both demand and supply sides. Section 8 concludes by providing a menu of additional research questions raised by the paper that are prerequisites for the design of appropriate policies to support greater uptake and use of internet and internet-enabled technologies for productive use.

2. What do we know about the impact of digitalization – a literature review

The world is undergoing a significant technological transformation that will reshape how and where businesses and households buy inputs, make, sell, and consume goods and services, and where more and better jobs are created—centered around internet-enabled, data-driven digital technologies. Digital technologies enabled by internet are "general purpose technologies" that reduce costs or frictions across the economy and allow better data-driven decision-making.[5] Digital technologies can be transformed through their productive use into increased economic opportunities for all enterprises and households.

Digital technologies refer to all technologies that capture, generate, store, modify, and transmit data through binary digits.[6] Digital technologies include internet, all types of software,

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[5] General purpose technologies, or GPTs, are transformational technologies. They include the steam engine at the time of the industrial revolution in the late 18th century, the electric motor in the late 19th century, and internet. GPTs are characterized by pervasiveness (used as inputs by many downstream industries), inherent potential for technical improvements, and enabling many positive spillovers. As GPTs are adopted across the economy, they generate economy-wide productivity gains. For a seminal article, see Bresnahan and Trajtenberg (1995).

[6] While radio signals on the initial 1G (first-generation) cellular networks were analog and converted data into electric rhythms of multiple amplitudes, radio signals on 2G and higher generation networks are digital. 2G phones also enable basic data services such as SMS (Short Message Service) text and picture messages. However, even 2.5G feature phones are typically too slow to enable productive use of internet beyond limited browsing—for which 3G and higher generation devices are required.

computers and tablets, internet-enabled smartphones (3G, 4G and 5G that combine computing and telephone functions into one unit, and progressively enable faster access to and processing of more data), digital cameras and video, geo-location, and digital platforms (software-based online marketplaces that intermediate by facilitating peer-to-peer transactions, matching buyers and sellers, and enabling crowd-based transactions). Importantly, computers, tablets, and smartphones enable access to the vast range of information and services available on internet. In addition to the linking of data collected by sensors on many different types of production and household goods through IoT (internet of things), other productivity-enhancing DTs include cloud computing, namely on-demand availability of data storage and computing power so that instead of buying the underlying expense hardware, enterprises and households can buy the associated on-line services on a per-use basis and discontinue use when no longer needed. They also include AI (artificial intelligence) offerings, typically supported by ML (machine learning), namely predictive analytic algorithms that improve over time with the use of increasingly large amounts of data. Other available DTs include blockchains, namely decentralized, distributed digital records linked together using cryptography to be resistant to modification of the underlying data and ensuring that the underlying data is tamper-proof, cryptocurrencies, namely digital money based on decentralized ledger technologies, and 3D printing or additive manufacturing, the construction of objects from a digital 3-dimensional computer graphic. Digital technologies help reduce different types of economic production and transaction costs, including search, replication, transportation, tracking, and verification costs.[7]

Faster internet in SSA as well as in NAfr and NRME regions was facilitated by the gradual arrival of submarine cables from Europe in the late 2000s and early 2010s that greatly increased speed and capacity on terrestrial networks.[8] For those enterprises and households located in the vicinity of these terrestrial networks, the probability that an individual is employed increases by 6.9 and 13.2 percent, respectively, for countries in different samples (Demographic and Health Surveys [DHS] across eight SSA countries and Afro barometer across nine SSA countries), and by 3.1 percent in South Africa, relative to areas unconnected to submarine cables (Hjort and Poulsen 2019). Importantly, the increase in jobs in these areas is not due to displacement of jobs in unconnected areas. These impacts attributable to faster internet are net positive job increases and sizable in magnitude. In terms of the skill content of jobs, faster internet adoption is skill-biased—that is, internet complements more skilled jobs, as has been shown in high-income countries. And in terms of educational attainment, even low-educated workers benefit, though workers that did not complete primary education were disadvantaged: the percentage change in the probability of employment was significantly positive in the range of 6 percent for workers with primary, secondary and higher education levels, but not statistically significant for workers not having completed primary education. In terms of the mechanisms through which faster internet availability increases jobs, part of the increase in

[7] Goldfarb and Tucker (2019) explore how standard economic models change as these costs fall substantially and approach zero. Monitoring costs are reduced by the joint fall in tracking and verification costs.

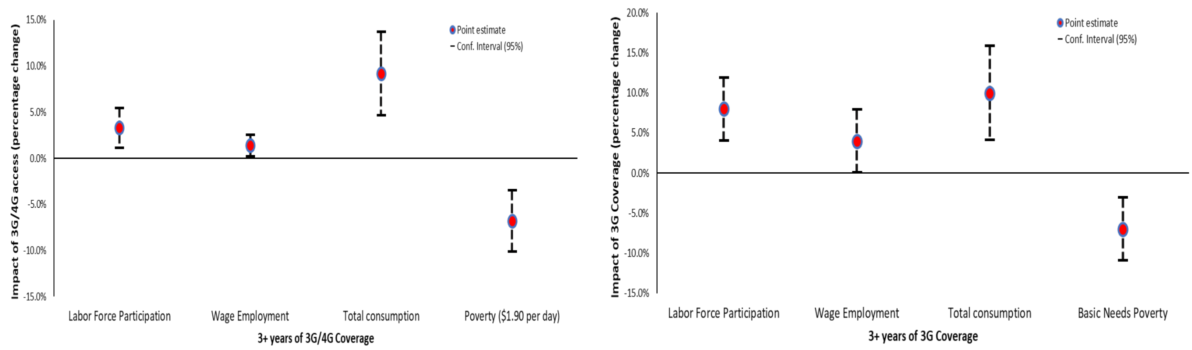
[8] This section and especially the first sub-section benefits from a useful recent literature review that divides available research on internet connectivity into supply-side and demand-side impacts. See Hjort and Tian (forthcoming).

jobs is explained by net firm entry (about 23 percent in South Africa), including a large increase in firm entry and a decrease in firm exit of similar magnitude. Another part of the jobs increase appears to be due to increased productivity in existing manufacturing firms (in Ethiopia). Enterprises in Ghana, Kenya, Mauritania, Nigeria, Senegal, and Tanzania export more when having access to faster internet, communicate with clients more, and train employees more, according to World Bank Enterprise Survey data. The productivity of lower-educated workers, those who only completed primary education, may have benefited from provision by employers of targeted on-the-job training.

Three subsequent country case studies – on Nigeria, Senegal, and Tanzania – have also added to this rapidly growing evidence base by exploring the impact of mobile internet availability (3G or 4G coverage) – instead of fixed terrestrial broadband – on jobs and welfare. The studies take advantage of geospatial information on the roll-out of mobile internet towers over time combined with at least two rounds of household data over a six to seven-year period. Figure 1 summarizes main jobs and welfare (consumption and poverty) results for Nigeria and Tanzania.

Figure 1: Internet availability increases jobs and household welfare

(a) Nigeria (b) Tanzania



Source: Bahia et al. (2020 and 2021). Notes: Difference-in-difference estimates with 95% confidence intervals. Each point represents the estimated impact of mobile internet coverage on labor and welfare outcomes. The reported effects on poverty in the graph are not comparable. For Nigeria, poverty status is defined based on the international poverty line of $1.90 per day. For Tanzania, the graph reports the impact of 3G coverage on basic needs poverty, which is derived based on the cost of buying adequate daily nutrition per person plus the cost of some non-food essentials.

The job estimates from Nigeria show that internet availability had positive impacts: labor force participation and wage employment increase by 3 and 1 percentage points respectively after three or more years of exposure in areas with internet availability relative to those with no coverage (Bahia et al., 2020).[9] The internet-induced improvement in labor market outcomes is

[9] The identifying assumption of causal effects is linked to the gradual deployment of mobile broadband over a 7-year 2010-16 period, based on GSMA coverage maps combined with 3 rounds of General Household Survey panel data. Controls include access to electricity, ownership of dwelling, household size, and an index related to

especially large for women. The internet availability causing these jobs effects also cause large and positive increases in household consumption levels: households with at least one year of mobile broadband availability increase total consumption by about 6 percent. These effects increase to about 9 percent after three or more years of mobile internet coverage. Mobile internet availability also reduces the proportion of households below the poverty line, driven by higher food and non-food consumption in rural households: the proportion of households below the poverty line reduces by 4 percentage points for extreme poverty after one year of gaining mobile internet availability, and by 7 percent after three years.[10] The welfare results are higher among poorer, and rural households, with results for urban households mostly statistically insignificant.

The job estimates for Tanzania are similarly significant, with richer jobs data allowing a more detailed exploration (Bahia et al., 2021).[11] Internet availability facilitates a transition out of farm jobs into wage and non-farm self-employment. Living in areas covered by mobile internet reduces farm self-employment by 7 percentage points after three or more years of coverage. Correspondingly, working age individuals living in areas with internet availability witness an increase in labor force participation, wage employment, and non-farm self-employment by 8, 4 and 4 percentage points, respectively, after 3 or more years of exposure. Younger (less than 30 years of age), more educated (greater than primary), and men benefit the most through higher labor force participation and wage employment. Differently to men, there is no effect of mobile internet availability on overall female labor force participation or wage employment. However, higher-skilled women, namely those literate and with at least completed primary education, do benefit from shifts out of farm work into non-farm self-employment and family enterprises.[12] The internet availability causing these jobs effects again also causes large and positive increases in household consumption levels: per capita total consumption among households residing in areas with 3G availability is about 10 percent higher than without coverage after three or more years of exposure. The proportion of households below the national basic need poverty line is reduced by 7 percentage points after three or more years of

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wealth measuring dwelling characteristics. In addition to testing for similarity of pre-treatment trends, additional specifications are run that exploit the fact that some households get 'unintentional' mobile broadband coverage, which is potentially quasi-random. Labor force participation is defined as those working age (15-64) individuals who were employed or unemployed (looking for a job) in the past 7 days. Working-age individuals who worked for someone who was not their family member during the last 7 days were considered to be salaried/wage workers. Main results are robust to specifications including self-reported access to internet as controls.

[10] Extreme and moderate poverty are US$1.90/day and US$3.20/day lines. Impacts on moderate poverty are not statistically significant.

[11] The identifying assumption of causal effects is again linked to the gradual deployment of mobile broadband, this time over a 6-year 2008-13 period based on GSMA coverage maps, combined with 3 rounds of the National Panel Survey.

[12] As reported in Bahia et al. (2021), these findings are consistent with previous studies which suggest that, while women can benefit from DTs, they often face greater difficulties to leverage them due to a mix of social norms, intra-household dynamics, lack of access of productive assets, and being less likely than men to use internet.

coverage.[13] There are higher welfare gains among households headed by female, poorer, or less-educated (not having completed primary) household heads.[14]

The job estimates for Senegal are also positive for some job categories: 3G availability is associated with 5 percent higher formal employment than non-covered areas, though availability does not have a significant impact on overall employment (Masaki et al, 2020).[15] The welfare estimates for Senegal also are aligned with findings for Nigeria and Tanzania, namely large effects on household consumption and poverty reduction.[16] Total consumption among households with 3G availability is 14 percent greater than non-covered households, while the average nonfood consumption of households with 3G availability is 26 percent greater than non-covered households. Households with 3G availability also exhibit an extreme poverty rate lower by 10 percent relative to households without coverage.[17] 3G availability is significantly and positively correlated with total consumption and negatively associated with poverty only for urban households; however, this correlation is particularly pronounced for food consumption among urban households, while 3G availability is significantly and positively correlated with non-food consumption for rural households, as well as for poorer households. The positive effects of 3G availability on non-food consumption are particularly pronounced among male-headed households. Splitting the sample by age (using age 50 as a threshold, roughly the median age of household heads), the positive welfare effects of 3G availability are more evident among households headed by younger people.

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[13] Impacts on the extreme and moderate US$ poverty lines are negative but statistically insignificant.

[14] In contrast to findings in Nigeria, there are higher welfare gains in urban areas. On the other hand, in contrast to consumption and poverty levels of female-headed households being statistically significant in Tanzania, they are not in Nigeria. One possible reason suggested for this is that in Nigeria, women can face significant barriers to using mobile internet relative to men, which might prevent them from reaping associated benefits: for example, women were 32% less likely than men to use mobile internet in 2017.

[15] Senegal findings are based on integrating two household budget surveys, the 2011 Deuxième Enquête de Suivi de la Pauvreté au Sénégal (Second Poverty Monitoring Survey, ESPS-II) and the 2017–18 Enquête Légère Expérimentale sur la Pauvreté (2017–18 Light Experimental Poverty Assessment Survey, ELEPS), with data on the expansion of mobile broadband coverage combining the Mobile Coverage Maps database by Collins Bartholomew and 2G-3G coverage information collected directly from the three major mobile operators in Senegal. The results are robust to controlling for household demographics (household size, the marital status and sex of household heads, access to electricity, literacy of household heads, and a wealth index related to housing conditions) and other spatial characteristics, including region fixed effects, road density, nighttime lights, and elevation above sea level, as well as for access to complementary digital infrastructure, such as 2G availability or fixed broadband internet. While 3G availability also is positively correlated with wage/salaried employment and earnings per month, these effects become insignificant with the additional set of controls.

[16] The welfare findings are also robust to an instrumental variable approach that relies on distance to 3G coverage in neighboring areas.

[17] While 3G availability is also correlated negatively with moderate poverty (based on the international poverty line of $3.20 per day), its effect is not robust to the inclusion of the additional set of controls.

Other empirical studies on SSA, NAfr and NRME regions explore indirect impacts on more and better jobs through effects of internet on improving firm-worker matching,[18] improving firm productivity through entrepreneurship, innovation and foreign investments, greater market access, reducing informational frictions, and boosting aggregate economic growth. The jobs to poverty reduction link, emphasized in the Nigeria, Senegal, and Tanzania studies, is not explicitly explored in most of these other studies. Given appropriate data on individuals, effects on poverty could also be explored through the impact of internet on consumer surplus gains to lower-income and less-educated people.[19]

Mobile money is the most prominent and best-known African digital technology that adds value to a digital phone. Launched in Kenya in 2007 by Safaricom, 97 percent of households had an M-PESA account as of 2014.[20] Robust causal evidence exists that better access to mobile money has led to better jobs and a reduction in poverty over time. In Kenya, the longer-term impacts of M-PESA include significant changes in occupation choice, largely among women. As a result of M-PESA, 186,000 women moved away from agriculture as their main occupation to business and retail. Better access to mobile money services also has increased financial resilience, with significant increases in total savings. Both labor market outcomes and increased financial resilience, in turn, are associated with increased household consumption and reduced poverty rates: poverty rates declined by 2 percentage points, with 196,000 households moving out of extreme poverty, and with reductions being larger among female-headed households (Suri and Jack, 2016).[21] In rural northern Uganda, rollout of mobile money agents doubled the nonfarm self-employment rate from 3.4 to 6.4 percent and reduced the fraction of households with very low food security from 62.9 to 47.2 percent, in areas far from a bank branch (Wieser et al., 2019).[22] Access to mobile money services also has been shown

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[18] Based on international data from 2000-17, Lederman and Zouaidi (2020) document a robust, negative partial correlation between long-term national unemployment rates (frictional unemployment) and internet use, proxied by the share of the adult population that reports using the internet to pay bills. The absolute values of ordinary least squares estimates of the partial correlation suggest that it might be higher for developing economies than high-income economies.

[19] Dutz et al. (2012) estimate a nested logit demand system with instrumental variables and allowing preferences to vary depending on the share of rural households in each metropolitan statistical area of the U.S. They find net U.S. consumer benefits from home broadband in 2008 in the order of US$ 32 billion per year. Additional willingness to pay for broadband is significantly higher for higher-income, younger, and more-educated (bachelors degree of more relative to high school diploma or less) households, suggesting that lower tariffs for lower-income, older, and less-educated households could yield higher uptake by these demographic groups.

[20] See Suri (2017) for an overview of the operations, regulations, and impacts of mobile money in developing countries.

[21] Between 2008 and 2014, five rounds of a household panel survey were conducted. To identify the causal effects of M-PESA on the economic well-being of households, changes in access to mobile money, not adoption itself, was used. Access to the service was measured by the geographic proximity of households to mobile money agents.

[22] The underlying question in the study is whether the sample areas are too remote and poor to benefit from mobile money (since they receive few remittances and may not have enough income to save). To measure the effect of mobile money in poor and remote areas, the International Finance Corporation (IFC) collaborated with Airtel Uganda to implement this RCT in Northern Uganda where none of the areas had Airtel Money agents at baseline.

to increase broad local economic activity: access increases the intensity of night-time lights by about 9 percent (Yokossi and Fabregas).[23] The positive effects are more pronounced for areas that are initially richer, urban, and connected to roads and banks. These results suggest that the presence of complementary infrastructure can strengthen the economic potential of mobile money, and are consistent with the idea that mobile money affects overall economic growth rather than just the redistribution of income from wealthier to impoverished areas—enabling lower-income people to connect, trade, and allocate investments within their networks.

A more recent DT innovation is the use of scoring rules or algorithms based on user transactions records to allocate financial credit. In 2011, Kenya's Safaricom partnered with a local bank in Kenya, the Commercial Bank of Africa, to create a new banking product called M-Shwari, which has become one of the most popular digital loan products in the world.[24] Robust evidence exists that such digital loans can dramatically lower the costs associated with lending and borrowing, leading to high uptake and improvements in household resilience to shocks, thereby reducing poverty (Suri, Bharadwaj, and Jack , 2021).[25] M-Shwari has an overall uptake of nearly 34 percent among the eligible population studied, and within two years those who initially qualified have 37 percent more loans. The uptake in household credit is entirely due to M-Shwari, not substituting for other forms of finance but truly expanding credit access.[26] The loans improve household resilience, and over the longer-term have the potential to reduce poverty, by

In the treatment group, Airtel Money agents were rolled out in 2017, with 46 percent of areas receiving at least one agent. The authors conclude that mobile money services can improve livelihoods even in very poor and remote areas, even though the analysis finds no direct effect on savings, agricultural outcomes, or poverty.

[23] Data are combined from the expansion of the mobile agent network in Kenya for the period 2000 to 2013 with a local-level measure of economic performance proxied by the intensity of night-time lights. To identify causal effects, the variation in local areas that gained access to mobile money services at different times is exploited, as well as the high resolution of the data, which allow for the inclusion of hyper-local fixed effects.

[24] To make a lending decision, the DT asks for permission to scrape the applicant's phone for data on handset details, GPS info, call and SMS logs (including airtime purchases and mobile money transactions), social network data from Facebook, and contact lists. A machine-learning algorithm then uses these data to create a credit score and make a lending decision. Increased use results in lower interest fees and larger loans. See Suri (2017).

[25] The identification strategy relies on a fuzzy regression discontinuity design of individuals around the cutoff point where they are just eligible or ineligible for the digital loan product, based on administrative data from the bank for customers that opened their accounts between January and March 2015. These data are combined with survey data conducted in September 2016-January 2017, and administrative data on a random sample of 10,000 M-Shwari customers who opened their accounts between January and March 2016 where the entire evolution of their loan histories and credit limits can be followed.

[26] This is important as households in the sample have extremely poor access to any form of formal credit, as they are made up of poor and vulnerable individuals: only 6% have had a bank loan over the two years prior

to the survey, only 2% have had a microfinance loan, only 5% have had a loan from a savings and credit cooperative and only 6% from a ROSCA (peer to peer lending).

enabling an increase in expenditure on education: households are 6.3 percentage points less likely to forego such expenses due to negative shocks.[27]

There is also some recent evidence on correlations between adoption of digital technologies and economic outcomes from firm level data in low- and middle-income countries. One source of findings is the Firm-level Adoption of Technology (FAT) surveys carried out by the World Bank and initially covering Ghana, Kenya, Malawi, and Senegal, together with Brazil and Vietnam. The FAT covers enterprises that have at least 5 employees. For each enterprise, it asks what technology is used most intensively for each of its general business functions (GBFs). For each GBF an index of technology use is calculated. While firms in Africa leg behind those in Vietnam and Brazil in terms of technology use, the findings show that the intensive use of more sophisticated digital and related technologies is associated with higher productivity across available enterprises in Africa. In Senegal, the association between productivity and technology use is higher among informal firms relative to formal firms, and higher in African firms relative to those in Brazil and Vietnam (Begazo Gomez, Blimpo and Dutz, 2022). The second source of findings is the Research ICT Africa (RIA) After Access business survey, which is focused on micro-size enterprises. Evidence from the RIA microenterprise survey shows that microenterprises that use DTs with internet-enabled computers or smartphones have higher productivity, sales, and jobs outcomes than non-users, and higher outcomes than those enterprises using only 2G phones, even after controlling for firm characteristics such as firm age, industry, whether the firm has access to electricity and whether the firm has a loan (Atiyas and Dutz, 2022).

The literature on the adoption of mobile and broadband services is extensive. Generally demographic characteristic such as education, income, gender, age and vocation are found to be correlated with adoption of internet services (Kongaut and Bohlin 2016 on Sweden; Nishijima et al. 2017 on Brazil; Goldfarb and Prince, 2008 on the US; Grazzi and Vergara, 2013 on Latin America; Silva et al. 2020 on Brazil; Martínez-Domínguez and Mora-Rivera on Mexico, 2020). Except for a few examples, papers that focus on SSA and MENA countries are relatively scarce. Hakim and Neaime (2013) examine mobile penetration in MENA countries. Bouali (2017) examines the effect of regulating mobile termination rates on mobile competition in Tunisia. Recent studies that focus on SSA include Gillwald et. al. 2010 and Stork, Calandro and Gillwald (2013), using microdata collected by Research ITC Africa (RIA), Birba and Diagne (2012), also using RIA data; Penard et. al. 2012 on Cameroon, using special survey on ICT services; Forenbacher et. al 2019 on Nigeria and Hasbi and Dubus (2020) on Nigeria, Kenya, Tanzania and Uganda, using data from Intermedia's Financial Inclusion Insights program. Cross-country studies on the SSA generally use micro data and do not directly address the question of what makes SSA or the MENA special.

[27] Roughly 68% of the control group reports having to forego some expenses in response to a negative shock. Even though households spend the actual loan money on, say, medication, the marginal dollar from the loan gets spent on education, the item they would have adjusted had they not had access to the loan.

3. The extent of coverage and use of mobile internet

We now turn to an analysis of coverage and especially uptake of mobile internet. Most of the analyses presented in the rest of the paper rely on aggregate data compiled by the International Telecommunications Union, the World Bank (World Development Indicators), GSMA and Telegeography. Working with such data has obvious limitations. It lacks the richness of individual, household, and firm level data that could specify not only internet use but the intensity of use of different digital technologies that internet enables. Aggregate data also do not differentiate between households and firms, so it becomes impossible to make distinctions between different intensities of use of internet across households and enterprises, and across different types of households and enterprises.[28] Some of the data lack continuity (e.g. data on skills and tariffs). Cross-country panel data on households as well as firms followed over time would allow strong causal inferences to be made. Ideally, such data should distinguish between digital and complementary technology use (the extensive margin, whether the technology is used at all) and their intensive use (whether more or less sophisticated technologies for the same business function are the most commonly used technology relative to other available choices, and how much each of these technologies is used) On the positive side, aggregate data have the advantage of the same data definitions covering many regions and countries, making comparisons across countries and regions possible. In a few instances, the analyses will refer to other studies that use micro-level data to provide additional evidence on drivers or conditional correlates of uptake.

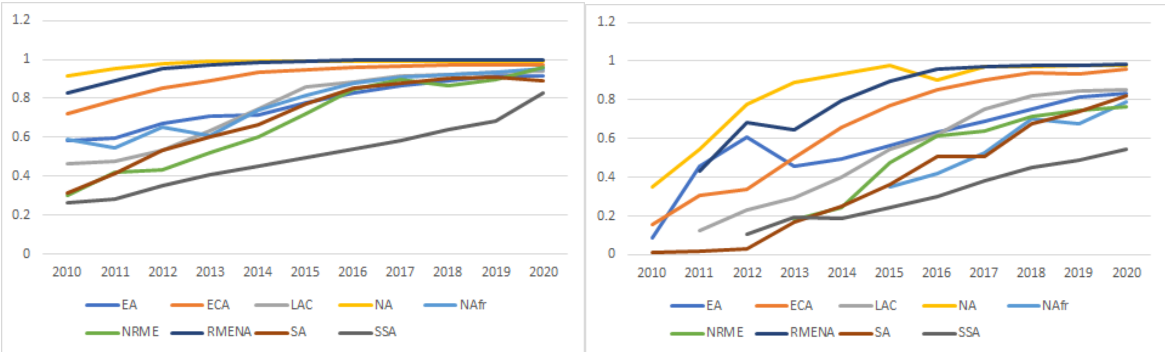
Figure 2 provides information on the percentage of the population covered by internet-enabled mobile telecommunications networks in different regions of the world. Panel a shows that convergence has occurred in availability of 3G networks in all regions over the past decade. Between 2010 and 2019, NRME countries tripled coverage, increasing from 30 to 90% and SSA countries increased coverage by 160%, from 26 to 69%, while NAfr, already at 59% coverage in 2010, increased 3G availability to 93%. A further major convergence occurred by SSA followed by the NRME countries over 2020, driven by increased investments likely already planned but perhaps accelerated in response to increased demand by existing users following the onset of the Covid pandemic. Over 2020, SSA increased coverage by a further 21%, while NRME increased coverage by 7%. By end 2020, 3G networks were available to at least 90 percent of populations in all regions (89 percent of the population in South Asia) except for SSA, where availability was still only at 83 percent. By contrast, availability of 3G networks in NAfr and NRME were closer to the frontier, with 95 and 96 percent of their populations

[28] Evidence suggests that some of the key drivers of uptake on the demand side are quite similar across households and firms: affordability, capabilities and skills, attractiveness of the technologies to users, and the existence of complementary assets such as electricity are important conditional correlates of uptake for both firms and households (Begazo-Gomez, Blimpo and Dutz, 2022). In addition, especially for the case of Sub-Saharan Africa, the distinction between firms and households is highly blurred for informal microenterprises that provide a large share of overall employment. This is most evident in the agricultural sector where the distinction between the household and the enterprise does not even exist for a significant share of sectoral employment. Still, the uses and intensity of use of different digital technologies that internet enables, their associated demand elasticities, the scope for substitution, and other factors likely differ, perhaps significantly, between households and firms, and between different types of households and firms.

covered by 2020. With regard to coverage of 4G networks (panel b), all regions have converged relatively quickly to the North American level over the past decade except SSA, having only 54 percent of its population with availability by end 2020. As a sign of slower investments in 4G coverage in SSA, the region had 4G coverage of almost 19 percent in 2013, ahead of South Asia (17 percent), while by 2020 availability in South Asia was 28 percentage points higher (82 vs 54 percent). To summarize, mobile internet availability in SSA has increased at a slower pace relative to the rest of the world over most of the past decade and still lags other regions, especially for 4G networks. By contrast, availability of 4G has reached 80 and 77 percent for NAfr and NRME, respectively. RMENA countries are at the global the frontier for both types of networks by 2020.

Figure 2: Percentage of population covered by mobile telecommunications networks

(a) 3G networks (b) 4G networks



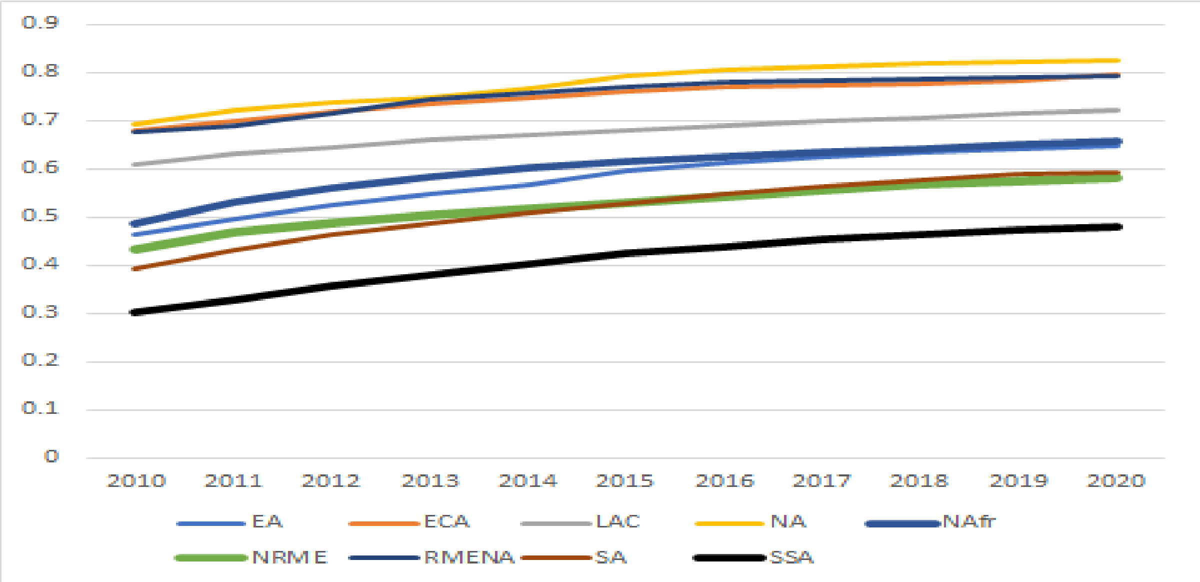
Source: GSMA. Note: EA: East Asia & Pacific; ECA: Europe and Central Asia, LAC: Latin America and the Caribbean; NAfr: North Africa; NRME: Non-rich Middle East; RMENA: Rich countries in Middle East and North Africa; NA: North America; SA: South Asia; SSA: Sub-Saharan Africa. For each region, unweighted means of country-level values are reported.

Uptake of mobile phone services (defined as unique mobile subscriptions as a percentage of the population) has increased significantly in SSA, NAfr and the NRME regions in the last decade (Figure 3).[29] However, despite an increase in use from about 30% to 48%, SSA still has less than half of its national populations, on average, using a mobile phone of any kind and lags

[29] There are many indicators that one can use to measure uptake of mobile and mobile internet services. A standard measure often used is number of subscribers divided by population. This is misleading because of the phenomenon of multiple sim cards. In many countries, especially in environments where switching between operators is costly, operators often use tariffs that differentiate between on net and off net calls to take advantage of tariff mediated network externalities. In addition, operators also often offer special discounts for specific patterns of calls or use of data, again as form of price discrimination. These types of practices lead many consumers to subscribe to more than one operator to take advantage of special discounts or avoid paying more to call people who are subscribers of other networks. As a result, the total number of subscriptions greatly overestimate the actual numbers of people who use mobile voice sms or data services. One way to get around this problem is to use numbers of unique subscribers compiled by the GSMA.

seriously behind the rest of the regions. Uptake of mobile services increased from 49 to 66% for NAfr and from 43 to 58% in NRME countries. The figure also shows that compared to the evolution of network investments and coverage on the supply side displayed in Figure 2, there is less of a convergence among regions on the demand side in terms of usage.

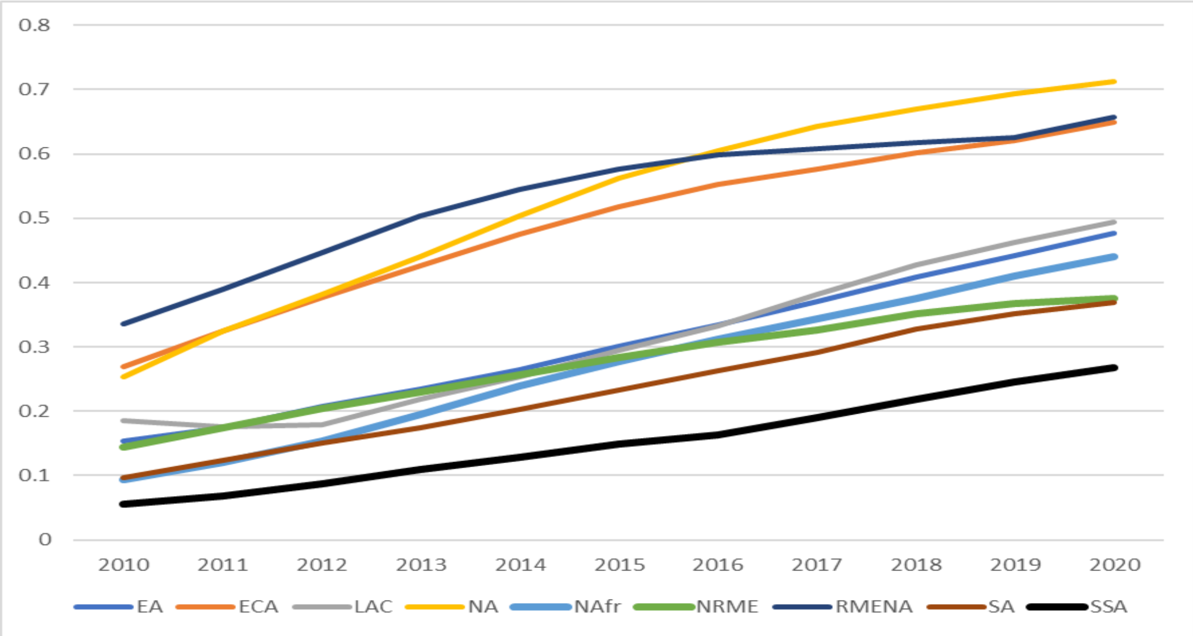
Figure 3: Unique mobile phone subscriptions as percentage of population



Source: GSMA. Note: Mobile phone subscriptions include 2G, 3G and 4G technologies. EA: East Asia & Pacific; ECA: Europe and Central Asia, LAC: Latin America and the Caribbean; NAfr: North Africa; NRME: Non-rich Middle East; RMENA: Rich countries in Middle East and North Africa; NA: North America; SA: South Asia; SSA: Sub-Saharan Africa. For each region, unweighted means of country-level values are reported.

The lack of convergence among regions on the demand side is even more clearly visible for unique subscriptions of mobile internet (Figure 4). There are three distinct groups of regions by 2020, with NA, ECA and RMENA having reached about 65-75% uptake, SSA with an uptake ratio of less than 30%, and the rest of the regions with subscriptions ratios of between 37-50%. Within the middle group, NAfr subscriptions for mobile internet have steadily increased throughout the decade, reaching 44% in 2020, whereas the pace of increase has slowed down in NRME in the second half of the decade, with a ratio of 38 percent in 2020.

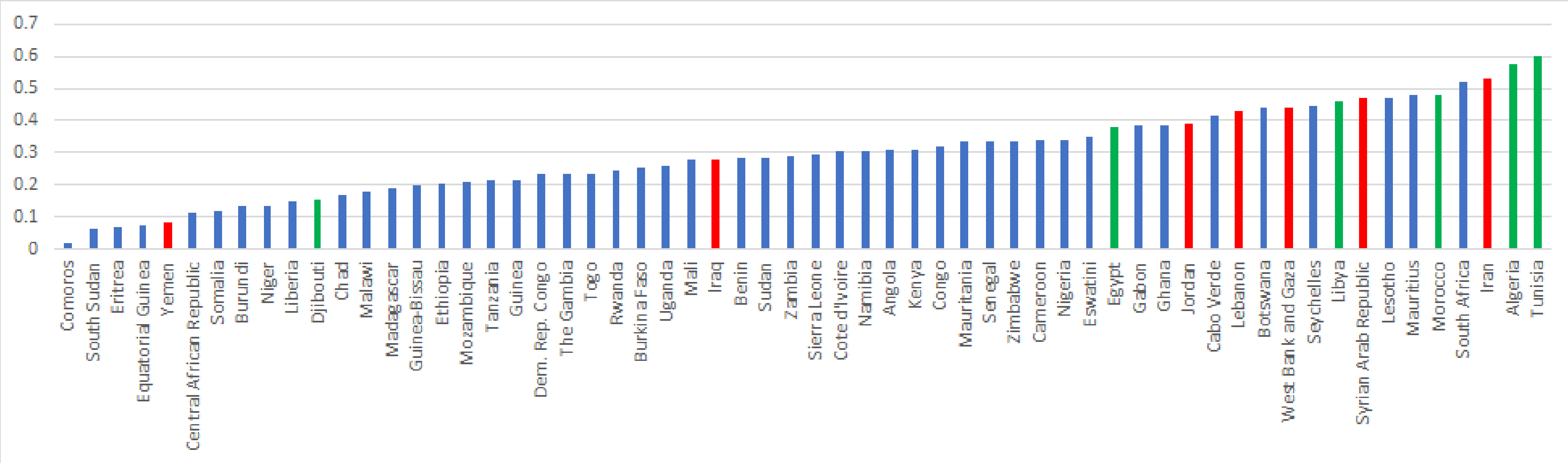
Figure 4: Unique mobile internet subscriptions as percentage of population



Source: GSMA. Note: Mobile internet subscriptions are restricted to 3G and 4G technologies. EA: East Asia & Pacific; ECA: Europe and Central Asia, LAC: Latin America and the Caribbean; NAfr: North Africa; NRME: Non-rich Middle East; RMENA: Rich countries in Middle East and North Africa; NA: North America; SA: South Asia; SSA: Sub-Saharan Africa. For each region, unweighted means of country-level values are reported.

The regional coverage and uptake averages conceal significant variation across countries within each region. As shown in Figure 5, in the case of SSA, mobile internet uptake varies between 2 percent in Comoros, 6-7 percent in South Sudan, up to more 40% in Lesotho, Mauritius, and South Africa. Ghana, Kenya and Senegal have uptake ratios of 30-40%. In NRME and NAfr, most countries have uptake ratios above 40 percent, though there are also exceptions that are more in line with lower-uptake SSA countries. In the case of NRME, unique mobile internet uptake varies between a low of 9% in Yemen followed by 28% in Iraq to a high of 53% in Iran. In the case of NAfr, the lowest uptake ratio is in Djibouti (15%) followed by 38% in Egypt and the highest is in Tunisia (60%).

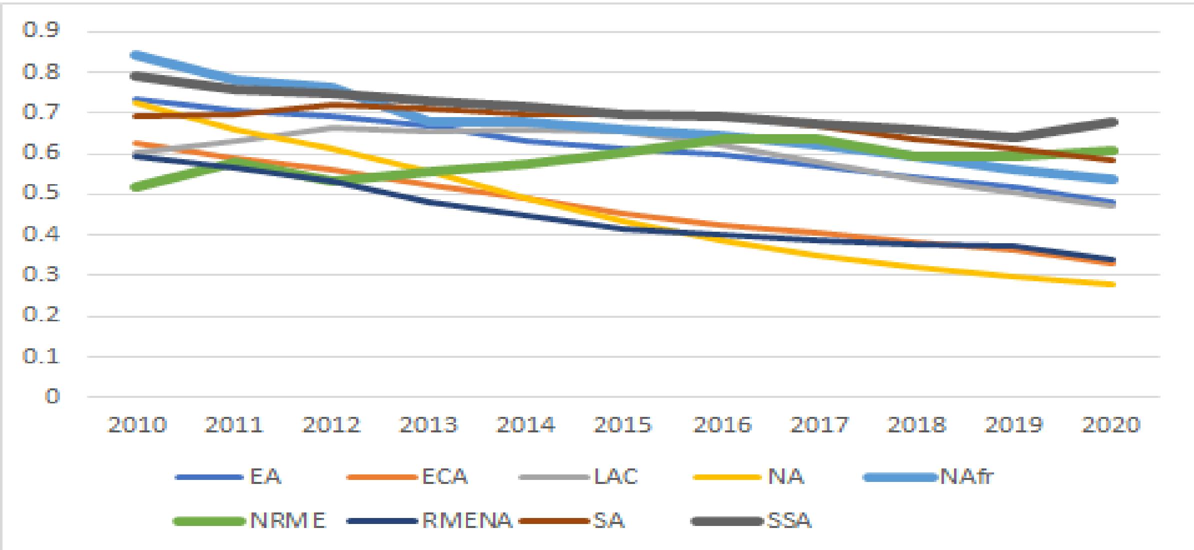
Figure 5: Unique mobile internet uptake in 2020 by country in the SSA, NAfr and NRME regions



Source: GSMA. Blue: SSA countries; Green: NAfr countries; Red: NRME countries

The contrast between coverage and uptake highlights that especially in the SSA region, there is a substantial part of the population that do not use mobile internet services even though they are available. Figure 6 reports a measure of the uptake gap, defined as the difference between coverage and uptake as a share of coverage, or in other words, a measure of the percentage of the population that have no subscriptions even though they are covered by at least a 3G network. The figure shows that uptake gaps have decreased over time in all regions. SSA has the largest uptake gap (68 % in 2020) and strikingly the gap has increased in 2020, reflecting the fact that during the COVID pandemic coverage has increased faster than unique mobile subscriptions. In NRME the uptake gap has increased in the first half of the decade and then remained almost constant afterwards. The evolution of the uptake gap in the NRME reflects the strong build-up of especially 3G networks throughout the decade (see Figure 2) and a comparatively slower increase in uptake. The decline in the uptake gap has been steeper in the NAfr region, from about 84% in 2020 to 54% in 2020. The persistence of the uptake gap especially in SSA suggests that accelerating uptake on the demand side may be a more critical policy issue than increasing coverage on the supply side.

Figure 6: Mobile internet uptake gap as a percentage of population covered



Source: GSMA. Note: Uptake gaps are defined as the difference between share of population with 3G coverage and mobile internet subscriptions as a percentage of the share of population with 3G coverage, and calculated as (1-(unique mobile internet subscriptions/3G+ coverage)). Eritrea is not included due to lack of data. Gaps are expressed as unweighted regional averages across countries (by giving equal importance to each country, heterogeneity across countries is highlighted).

The relatively low levels of coverage and uptake in the SSA region could be fully a reflection of the level of economic development of the countries in the region. More generally, both coverage and mobile internet subscriptions are expected to be highly correlated with the overall level of per capita incomes. If that is the case, comparing coverage and uptake without adjusting for income may be misleading. One way to explore this possibility is to run simple ordinary least squares (OLS) regressions on regional dummies controlling for GDP per capita. Table 1 reports the results of this exploration. The table reports the results of simple OLS regressions of indicators of coverage and uptake on regional dummies, controlling for GDP per capita (international constant PPP).[30] To allow for non-linearities, squared and cubed GDP per capita are included as additional controls.[31] The first row shows that after controlling for per capita income, SSA still has lower coverage and lower uptake than the rest of the world. Hence the gap in coverage and uptake between SSA and the rest of the world is not only due to differences in the level of economic development as summarized by per capita income. Column 3 shows that unique mobile uptake is about 7 percentage points below the rest of the world whereas column 4 shows that unique mobile internet uptake is about 6 percentage points lower. By contrast, after controlling for per capita income, coverage and uptake in NAfr and NRME are not different from the rest of the world. The explanatory power of the equations is quite high, about 60 percent in the case of coverage and 70 percent in the case of uptake - emphasizing that per capita income is a strong predictor of the demand side of uptake on average across regions.

Table 1: Are Africa and MENA different from the rest of the world?

	(1)	(2)	(3)	(4)
VARIABLES	3G network coverage	4G network coverage	mobile uptake	mobile internet uptake
SSA	-0.157***	-0.137***	-0.0694***	-0.0618***
	(0.0318)	(0.0357)	(0.0247)	(0.0201)
North Africa	0.0567	-0.0503	0.0357	-0.0136
	(0.0523)	(0.0887)	(0.0449)	(0.0344)
Non-rich Middle East	-0.0536	-0.0487	-0.0442*	0.0232
	(0.0820)	(0.128)	(0.0246)	(0.0324)
Constant	0.396***	-0.316***	0.319***	-0.00547
	(0.0294)	(0.0598)	(0.0283)	(0.0192)
Observations	1,976	1,322	2,108	2,084
R-squared	0.589	0.626	0.701	0.714

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Source: GSMA and WDI. Note: OLS results based on a panel of data from all available countries worldwide by year over 2010-2020. The dependent variables are reported at the top of the columns. In addition to the reported regional dummies, all regressions include year dummies and GDP per capita (international constant PPP, from the World Development Indicators), GDP per capita squared and GDP per capita cubed. The coefficients of the last three are significant at the 1 percent level in all four equations. Errors are clustered around countries.

[30] Full results of these regressions and all others conducted for this paper are presented in Annex 2.

[31] The coefficients on the controls are statistically significant at 1 % in all equations.

Needless to say, per capita income is not exogenous to coverage and uptake, in part because higher uptake of mobile services or mobile internet services are expected to have a positive impact on GDP per capita or on its growth rate, as indicated by the recent literature (e.g. Myovella et. al. 2020). In addition, GDP per capita is also correlated with many of the variables that are believed to drive uptake that are omitted here (but examined below). Such drivers include factors such as the ability of users to benefit from these applications or more generally from various services that can be obtained in the digital world (largely determined by education and skills and the quality and extent of benefits that such training provides), the price of the offerings (telecom services plus handsets) relative to income and earnings generated, the affordable availability of complementary electricity infrastructure, as well as the regulatory regime, market structure and competition that are expected to affect availability and price levels on the supply side of internet offerings. Hence the results reported in Table 1 should be interpreted as useful reduced form associations summarizing complex interactions among a multitude of factors. The following sections explore some of these main factors, first those affecting mobile internet demand, and then those affecting mobile internet supply.

4. Factors Affecting Mobile Internet Demand

Factors affecting mobile internet demand can be summarized under three main headings: capabilities, affordability, and attractiveness. Capabilities affect the degree to which users can generate utility of value from DTs. Capabilities are influenced by basic education as well as follow-up technical and vocational education and training. For firms, capabilities also depend on technical production-related features such as the complexity of production processes, the sophistication of suppliers and customers, and the extent to which managers make use of DTs and DTs in turn contribute to enhance managerial practices. Affordability includes availability as well as price (relative to household budgets or firm revenues). Relevant prices include prices of voice and data packages offered by operators as well as prices of handsets. Finally, attractiveness refers to willingness to pay, including factors that make mobile internet services valuable for users. Attractiveness is affected by availability of information on the existence of DTs and on how to use them. It depends on the availability of applications that are useful to users in terms of increasing their utility or productivity. These factors are not necessarily mutually exclusive and divisions between them may not always be clear, but this categorization helps to facilitate the analysis. In addition to these main factors, uptake is often also influenced by the availability and affordability of complementary infrastructure (such as electricity), other elements of the business environment (for example availability of finance and entry barriers), and other socio-economic factors (for instance social norms that discriminate against women).

We start with an assessment of capabilities. These range from basic literacy and numeracy skills obtained in formal education to more specific skills related to using internet and very specialized digital skills necessary to design new software programs or to adapt existing software to new contexts. Unfortunately, systematic data on capabilities exist only for a small subset of these dimensions. Some aggregate—admittedly imperfect—indicators of education and skills are presented in Table 2. The first four indicators are calculated from the Human Capital Index data set of the World Bank for 2020. Expected years of schooling are calculated based on enrollment rates from UNESCO, "extensively revised/updated/expanded with estimates provided by World Bank staff' (Kraay, 2018). How this updating is done is not explained. Harmonized test scores are calculated based on several international and regional testing programs (as explained in Kraay, 2018) and therefore can be used as an indicator of quality of schooling. "Learning adjusted years of schooling" adjusts the schooling variable using the test scores. Data for columns 4-7 are from the World Development Indicators. Data on enrollment refers to the year 2017 and those for literacy refer to the year 2018, because those are the years with fewer missing values.[32]

The table shows that the SSA region has the lowest score on all indicators except for gross primary school enrollment—and especially low relative to comparators for expected and learning-adjusted years of schooling, and gross secondary enrollment. The last two columns present an interesting comparison for SSA: literacy is higher for its younger population. This is consistent with findings, to be reported below, from micro data that younger people are more likely to have mobile internet subscriptions. NAfr and NRME regions have similar levels of the human capital index.

Table 2: Indicators of education and skills

	Expected Years of Schooling	Harmonized Test Scores	Learning Adjusted Years of Schooling	Primary enrollment gross	Secondary enrollment gross	Adult literacy	Youth literacy (15-24 ages)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
EA	11.91	432.11	8.35	105.30	97.10	93.60	97.46
ECA	13.05	479.40	10.05	101.18	109.70	99.01	99.67
LAC	12.06	404.54	7.82	104.50	94.11	94.73	98.79
NA	13.31	522.90	11.14	101.38	106.36	NA	NA
NAfr	11.07	373.64	6.61	103.11	71.48	77.58	97.58
NRME	10.07	391.51	6.41	96.80	79.29	96.84	99.48
RMENA	12.94	436.04	9.05	103.04	105.08	95.92	99.17
SA	10.75	373.72	6.46	107.96	71.02	70.19	88.31
SSA	8.30	373.81	5.01	103.76	51.94	67.25	77.56

Source: HCI and WDI. Note: Unweighted average of country values. Columns 1-3 are from the Human Capital Index (HCI) 2020 data set of the World Bank. Columns 4-7 are from World Development Indicators and refer to 2018 for literacy and 2017 for enrollment. The WDI data contain missing values for many countries.

[32] For literacy, for the year 2018, 46 percent of countries in SSA have missing values. For NRME and NAfr, the ratios are 57 and 67 percent respectively. For secondary enrolment ratio for the year 2017, 48% of observations in SSA, 57 of NRME and 50 percent of NAfr are missing.

How strongly are these capability-related variables correlated with mobile internet uptake? Table 3 reports the results of regressions of unique mobile internet uptake on skills-related indicators. Columns 1 to 5 report results of pooled OLS regressions with year effects. For columns 1-3, the right-hand side variables are from the HCI data set and cover years 2017, 2018 and 2020. Results show that unique mobile internet uptake is positively correlated with these indicators of skills and the correlation is highly significant. In columns 4-6, the right-hand side variables are from the WDI, covering years 2010-2020 but with a lot of missing values as mentioned above. The correlations are positive and significant. Columns 7-9 repeat the exercise of columns 1-3 but this time with country fixed effects. The coefficients are still positive but statistically not significant. This is most likely due to the fact that the skills variables show too little variation across years within most countries. The findings suggest that the lower average capabilities of people in SSA as reflected by their lower educational attainments are a significant associate of lower uptake. In addition, the higher coefficient of determination (R-squared) values in these regressions, in the range of 75-80%, relative to those where only per-capita income is included (71% as reported in Table 1), suggest that capabilities variables have additional explanatory power beyond income as an important set of factors associated with uptake.[33]

Table 3: Conditional correlates of mobile internet uptake: Skills (2010-2020)

Dep.variable: Unique mobile internet uptake	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Expected years of schooling	0.0197***						0.00669*		
	(0.00400)						(0.00354)		
Harmonized Test Scores		0.000703***						7.59e-05	
		(0.000199)						(0.000221)	
Learning-Adjusted Years of Schooling			0.0285***						0.00639
			(0.00514)						(0.00697)
Literacy rate, youth total					0.00174***				
					(0.000597)				
Literacy rate, adult total				0.00176***					
				(0.000540)					
School enrollment, secondary gross						0.00179***			
						(0.000490)			
Constant	-0.0175	-0.103	0.0164	-0.154***	-0.179***	-0.125***	0.231*	0.264	0.245*
	(0.0308)	(0.0688)	(0.0232)	(0.0315)	(0.0418)	(0.0227)	(0.124)	(0.163)	(0.137)
Observations	490	483	483	424	418	1,217	490	483	483
R-squared	0.806	0.809	0.820	0.746	0.752	0.751	0.728	0.728	0.729
Number of country							172	171	171

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Source: GSMA, HCI and WDI. Note: All regressions include year fixed effects and GDP per capita (international constant PPP, from the World Development Indicators), GDP per capita squared and GDP per capita cubed. Errors are clustered around countries. Right hand side variables for columns 1-3 are obtained from the Human Capital Index data set of the World Bank and they exist for the years 2017, 2018 and 2020. Those for columns 4-6 are from World Development Indicators, covering the period 2010-2020 but with large numbers of missing values.

[33] The reader is reminded that regressions reported in Table 1 include some regional dummies and those in Table 3 do not.

Evidence on the importance of skills is also available from studies that use household-level microeconomic data rather than national aggregates. Table 4 shows results from a multinomial logit analysis of adoption of mobile services across 9 SSA countries with over 12,000 households (Atiyas and Doganoglu, 2021). In the model, the dependent variable takes three values, namely not using any mobile services, using mobile services without data (i.e., only voice and SMS), and using mobile internet. Rather than reporting the coefficients of the estimation, we report average marginal effects. Specifically, the values in the table show the average probabilities of using the respective services at different levels of education (measured in terms of years of schooling), controlling for income, wealth, whether the household has electricity, years of schooling, age, the number of friends who use mobile services, and the number of friends who use mobile data, as well as country fixed effects. The reported results show that moving from 0 to 5 years of education increases the probability of using mobile internet from 5 to 8 percent. At ten years of education (just below finishing high school), the probability of using mobile internet is increased to 12 percent. An increase in the years of education to 15 years increases the probability to 18 percent. The first column shows that the probability of not using a mobile phone declines with increases in years of schooling.

Table 4: More education leads to higher probabilities of using mobile services with data

Levels of SchoolYears	No Mobile	Mobile with no Data	Mobile with Data
0	0.4762***	0.4781***	0.0457***
	(0.0131)	(0.0192)	(0.0091)
5	0.3780***	0.5447***	0.0773***
	(0.0041)	(0.0102)	(0.0081)
10	0.2875***	0.5919***	0.1206***
	(0.0039)	(0.0032)	(0.0032)
15	0.2079***	0.6162***	0.1759***
	(0.0085)	(0.0137)	(0.0067)
Observations	12,437	12,437	12,437
Standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

Source: Atiyas and Doganoglu, 2021, based on RIA data. Note: Results from a multinomial logit estimation where the dependent variable takes on the values "using no mobile services", "using mobile services without data" and "using mobile services with data". The table reports average probabilities of the three outcomes at different levels of schooling. The data are from individual and household surveys implemented by Research ICT Africa (RIA) over 2017-18 and covers 9 SSA countries - Ghana, Kenya, Mozambique, Nigeria, Rwanda, Senegal, South Africa, Tanzania, and Uganda (12,400 observations). Regressions include country fixed effects and control for income, wealth, whether the household has electricity, years of schooling, age, the number of friends who use mobile services, and the number of friends who use mobile data.

The RIA data set mentioned in the previous paragraph has some additional revealing information regarding barriers to adoption of mobile internet services. The survey asks "What is the main reason you do not use internet?" Table 5 reports the responses for countries where at least 50 percent of respondents answered the question. In the four countries, about 27 percent of the respondents do not know what internet is. An additional 10 percent report not knowing how to use it. A further 10 percent do not find internet useful, bringing the total to 47 percent. 13 percent report that they do not have an access device.

Table 5: Reasons for not using internet: Responses across 4 SSA countries

	Kenya	Ghana	Nigeria	Senegal	Total
I don't know what the internet is	13.6	28.3	30.3	32.9	26.8
No interest/not useful	17.8	7.8	7.7	6.2	9.6
I don't know how to use it	7.1	10.7	12.9	9.1	10.3
No access device (computer/smartphone)	15.2	18.2	9.5	9.4	12.6
Not available in my area (no mobile cov	1.5	1.4	2.0	1.4	1.6
Too expensive	3.0	1.8	2.7	1.1	2.2
No time, too busy	2.6	3.0	2.6	4.3	3.1
None of my friends use it	0.2	0.5	0.2	0.1	0.2
Lack of content in my language	0.3	0.3	0.3	0.6	0.4
Worried about privacy invasion over the	0.4	0.3	0.3	0.0	0.2
My spouse or parents do not allow me to	0.5	0.3	0.7	1.2	0.7
Other	1.5	1.4	1.2	1.7	1.4
No answer	36.3	25.9	29.7	32.0	30.9
Total No. of observations	1,208	1,200	1,808	1,233	5,449

Source: RIA Household and Individual survey (2017-18). Note: The table shows responses to the question: "What is the main reason why you do not use the internet?". Countries where the response rate was above 50 percent are reported, namely Ghana, Kenya, Nigeria, and Senegal.

Another set of factors of interest is related to affordability. The importance of affordability is partly reflected in the fact that variations in per capita GDP explain over 70 percent of the variation in unique mobile internet uptake. Clearly, affordability depends on prices offered by operators as well as the purchasing power of individuals. Operators often offer a wide range of packages. It is therefore difficult to compare prices across countries. One source of comparable prices is the International Telecommunications Union (ITU). ITU collects data on offers by operators and constructs prices for pre-determined consumption baskets that can then be compared across countries.[34] Table 6 presents information on three sets of services. The first is mobile data only, consisting of 1.5 GB of data per month. The second package is "mobile voice and data services – low usage" and consists of 70 minutes of voice, 20 SMS, and 500 MB of data per month provided over 3G networks or above. The third package is "mobile voice

[34] ITU has published two different series of prices consisting of different packages which are not comparable. The firs set covers the period 2013-2017 and the second covers the period 2018-2020. We use the more recent set.

and data services – high usage" and consists of 140 minutes of voice, 70 SMS, and 1.5 GB of data per month.[35] Chen and Minges (2021) estimate that for "foundational online activities, which include websites for public services, health information, shopping, and learning" about 660 MB of data are needed per month. They further state that "for common recreational online activities – particularly social media use – we estimate that an additional 5.2GB per month, per user are needed, for a total of approximately 6GB per month, per user." Hence the low usage package compiled by ITU provides a bare minimum of data. The high usage package is not very high at all. Information on prices is also reported in three different units. The first is current US dollars. The second is as a percentage of per capita GNI. The Broadband Commission for Sustainable Development's target for affordability is that by 2025, broadband prices should be less than 2 per cent of monthly GNI per capita. The third is prices adjusted for purchasing power parity (PPP). The table shows that prices in current USD in SSA are higher than those in NAfr for all three baskets. Prices in NRME are higher than both. The lowest prices are to be found in the SA region. This shows that before adjusting for income, NRME and SSA prices are relatively high. The difference is starker for the high usage package. Still, it should be emphasized that prices in SSA and NAfr are much lower than richer regions, including Latin America. Low nominal prices, however, do not mean that services are affordable when potential consumers have low budgets. Hence information on cost of packages as percentage of GNI provides an idea about affordability relative to income. With that criteria, mobile internet is clearly least affordable in SSA. The low usage package for voice and data is about 12 percent of GNI in SSA and only 1.9% in NAfr. In NRME it is in-between at 3.4% of GNI, yet still higher than the 2 percent target. The high usage package is even less affordable in SSA at 20 percent of monthly GNI. High usage prices are less affordable in all regions. In NAfr as well, the cost amounts to 2.8% of GNI. The comparison of nominal USD prices and prices as percentage of GNI underlines the acute affordability problem especially in low income countries. We should also note that, again, regional averages hide significant variation across countries. For example, the price for the high package varies between about 5 USD in Nigeria and 22 USD in Malawi and South Africa. Similarly, in the NAfr and NRME regions, it varies between 5 USD in Tunisia and 48 USD in Lebanon.

[35] Details on the methodology for the construction of ITU consumption baskets can be found at https://www.itu.int/en/ITU-D/Statistics/Pages/ICTprices/default.aspx

Table 6: Prices of mobile data services across regions in 2020

	Mobile Data only 1.5GB			Mobile data and voice low usage package			Mobile data and voice high usage package		
	USD	% of GNI	PPP	USD	% of GNI	PPP	USD	% of GNI	PPP
EA	13.0	2.7	17.9	15.5	3.4	22.8	22.7	5.9	34.1
ECA	12.4	1.0	17.6	13.6	1.1	20.1	16.7	1.3	24.5
LAC	18.5	2.7	28.0	24.3	3.5	36.2	28.1	4.5	40.8
NA	23.4	0.5	23.9	47.8	1.1	49.2	53.2	1.2	54.6
NAfr	6.5	1.9	14.5	6.8	1.9	15.8	9.7	2.8	23.5
NRME	12.5	3.9	27.5	12.8	3.4	27.4	22.8	6.0	48.5
RMENA	18.1	0.7	28.5	15.2	0.6	23.5	22.3	0.9	35.7
SA	3.9	2.6	10.4	4.2	3.5	12.7	7.1	5.5	20.6
SSA	7.1	8.4	18.1	9.9	12.3	25.1	16.9	20.4	42.7

Source: ITU.

Table 7 provides results of cross-country regressions on measures of affordability, namely prices for mobile data only, voice and data low usage and voice and data high usage, expressed as percent of GNI, current USD and PPP for the years 2018- 2020. The first 9 columns show results of pooled OLS regressions with year fixed effects and controlling for per capita income (per capita GDP in PPP constant prices, as well as its square and cube). Results show that mobile internet uptake is negatively correlated for all the measures. Columns 10-18 also include country fixed effects and the coefficients become insignificant. Once one controls for unobservable country characteristics, the conditional correlation between mobile internet uptake and process is calculated on the basis of within country variation over time. Insignificance of coefficients is likely reflecting the fact that within variation in prices is relatively small relative to variation across countries. The findings suggest that affordability is another important associate of lower uptake: income together with prices of voice and data packages have a coefficient of determination (R-squared) of almost 80% in the pooled OLS regressions. Affordability appears to represent a most important set of factors associated with uptake.

Table 7: Conditional correlates of mobile internet uptake: Prices (2018-2020)

Dependent variable: Mobile internet uptake	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
GNIpc mobilebbdata15GB	-0.00371**									0.000241								
	(0.00176)									(0.000350)								
GNIpc mobiledatavoicelow		-0.00333***									4.76e-05							
		(0.000615)									(0.000198)							
GNIpc mobiledatavoicehigh			-0.00170***									-9.02e-06						
			(0.000437)									(0.000133)						
PPP mobilebbdata15GB				-0.00335***									0.000363					
				(0.000690)									(0.000332)					
PPP mobiledatavoicelow					-0.00175***									1.13e-05				
					(0.000528)									(0.000158)				
PPP mobiledatavoicehigh						-0.00101***									4.19e-05			
						(0.000302)									(8.02e-05)			
USD mobilebbdata15GB							-0.00425***									0.000573		
							(0.000957)									(0.000462)		
USD mobiledatavoicelow								-0.00282***									0.000106	
								(0.000734)									(0.000240)	
USD mobiledatavoicehigh									-0.00188***									6.44e-05
									(0.000506)									(0.000142)
Constant	0.210***	0.219***	0.215***	0.232***	0.215***	0.219***	0.196***	0.193***	0.199***	0.418***	0.421***	0.422***	0.407***	0.420***	0.418***	0.409***	0.419***	0.420***
	(0.0242)	(0.0198)	(0.0212)	(0.0192)	(0.0204)	(0.0207)	(0.0161)	(0.0169)	(0.0179)	(0.0667)	(0.0682)	(0.0689)	(0.0755)	(0.0796)	(0.0781)	(0.0646)	(0.0666)	(0.0665)
Observations	535	530	533	503	498	500	542	540	540	535	530	533	503	498	500	542	540	540
R-squared	0.776	0.780	0.775	0.776	0.763	0.757	0.780	0.772	0.769	0.698	0.696	0.696	0.701	0.696	0.696	0.699	0.694	0.694
Country Fixed Effects	No	No	No	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Source: GSMA and WDI. Note: All regressions include year fixed effects and GDP per capita (international constant PPP, from the World Development Indicators), GDP per capita squared and GDP per capita cubed. Errors are clustered around countries.

Another critical driver of mobile internet uptake is the presence of network effects. This is captured in RIA survey through the following question: "thinking about your 5 closest friends how many who have an email address," "… how many use social media" and "…use messaging". Atiyas and Doganoglu (2021) use the average of the responses to these questions to create a variable (FriendsUseData) that captures the number of friends who use data. They use this variable in the multinomial model of adoption of mobile internet services mentioned above. The results of this exercise is reported in Table 8. The table reports average probabilities of using mobile services without data and mobile services with data at different levels of number of friends who use mobile data services. The results show that moving from 0 to 3 friends who use mobile data services is associated with an increase in the probability of using mobile internet from 3 to 16 percent. Moving to 5 friends is associated with a probability of using mobile data of 35 percent, reflecting a strong presence of network effects.

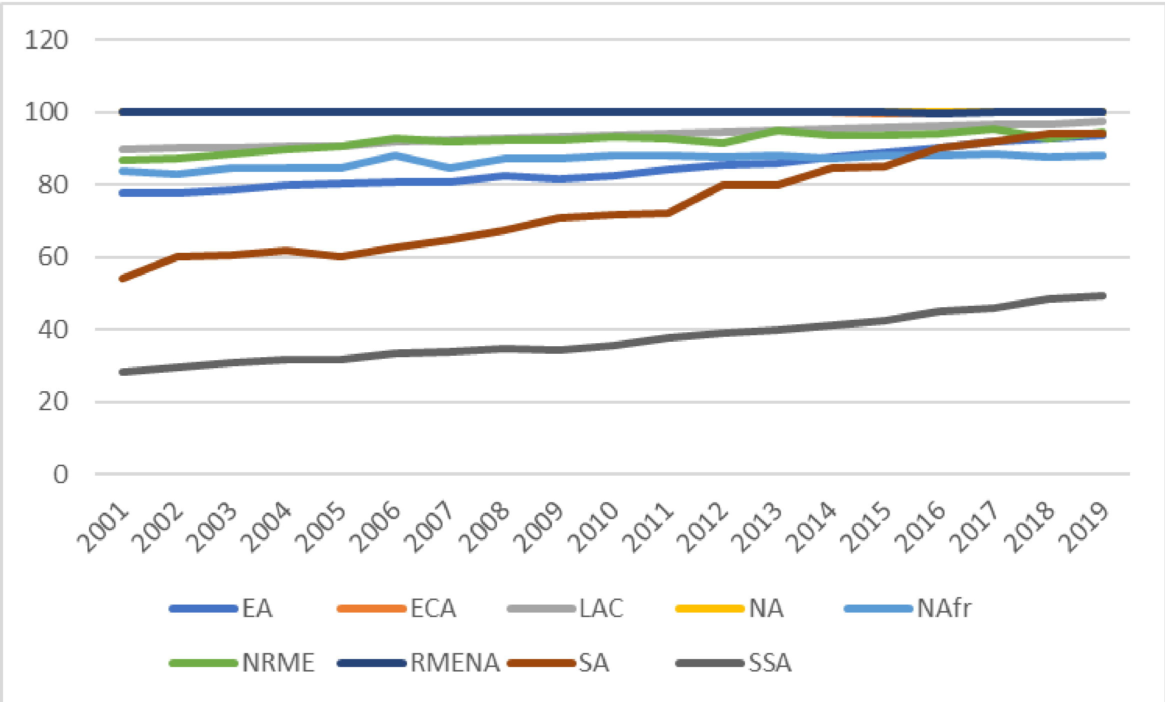
Table 8: A higher number of friends using mobile data services is associated with a higher probability of using mobile internet

Levels of FriendsUseData	No Mobile	Mobile with no Data	Mobile with Data
0	0.3537***	0.6139***	0.0323***
	(0.0038)	(0.0049)	(0.0030)
1	0.3395***	0.6018***	0.0587***
	(0.0040)	(0.0037)	(0.0035)
2	0.3230***	0.5757***	0.1013***
	(0.0108)	(0.0093)	(0.0033)
3	0.3035***	0.5325***	0.1640***
	(0.0171)	(0.0144)	(0.0035)
4	0.2804***	0.4724***	0.2472***
	(0.0225)	(0.0184)	(0.0063)
5	0.2537***	0.4000***	0.3463***
	(0.0269)	(0.0211)	(0.0113)
Observations	12,437	12,437	12,437
Standard errors in parentheses			
*** p<0.01, ** p<0.05, * p<0.1			

Source: Atiyas and Doganoglu, 2021, based on RIA data. Note: Results from a multinomial logit estimation where the dependent variable takes on the values "using no mobile services", "using mobile services without data" and "using mobile services with data". The table reports average probabilities of the three outcomes when at different levels of "number of friends using data services". The data are from individual and household surveys implemented by Research ICT Africa (RIA) over 2017-18 and covers 9 SSA countries - Ghana, Kenya, Mozambique, Nigeria, Rwanda, Senegal, South Africa, Tanzania, and Uganda (12,400 observations). Regressions include country fixed effects and control for income, years of schooling, wealth, whether the household has electricity, years of schooling, age, and the number of friends who use mobile services.

Recent analyses of adoption of mobile voice and data services has underlined the role of a key complementary asset, namely electricity (e.g. Houngbonon et al., 2021, Rodríguez-Castelán et al. 2021). Access to electricity is crucial, if anything, because of the need to power phones or other access devises. Figure 7 presents information on the evolution of the percentage of each region's total population with access to electricity. The figure shows that there has been a significant amount of convergence for all regions except for SSA. As of 2019, only about 50 percent of the population in SSA had access to electricity, compared to 88 percent in NAfr and over 90 percent in the rest of the regions. The gap is even starker among the rural population, with only 32 percent of population with access in SSA compared to 84 percent in NAfr and 91 percent in NRME.

Figure 7: Electricity access (percent of overall population)



Source: World Development Indicators.

As an additional possible conditional correlate of uptake on the demand side, we explore the role of inequality. Inequality may affect internet demand because affordability is closely linked to how incomes are distributed across individuals or households. Hence uptake of mobile internet services may be associated with differing patterns of distribution of income or degrees of inequality across countries. A priori the correlation between mobile internet uptake and inequality could be expected to go either way. In general, high inequality often implies that a large section of the population has low earnings, so a negative association between inequality and mobile internet uptake could be expected. But in some specific circumstances, a positive association could also occur. For example, in a country where average per capita income is very low, a high degree of inequality could imply the existence of a small but very high-income, high-purchasing power group of consumers that could generate high positive demand for internet services, in terms of use and especially in terms of intensity of use, compared to an equally poor country where income is distributed more evenly. Hence at low levels of average income or average uptake, a positive relation between uptake and inequality should not be surprising.

Table 9 presents information on two indicators of inequality, namely the income share of the top 1 and 10% of households by regions in 2019. With respect to the income share of the top 1 percent of households, Latin America has the highest figure (21%) followed by NRME, RMENA, SA and SSA. The ranking of regions changes when one focuses on the income share of top 10 percent, with SSA, NRME and RMENA ranking highest with 51 percent followed by LAC at 49 percent. Inequality in NAfr is lower than SSA and NRME by both measures.[36] There is significant heterogeneity within regions. In the case of SSA, for example, the share of top 10 percent varies between below 43 percent in Mauritania, Mali, Guinea and Nigeria and 65% in South Africa, Mozambique and Central African Republic.

Table 9: Income share of top 1 and 10 percent of households (2019)

	Income Share of top 1 percent	Income Share of top 10 percent
EA	0.15	0.43
ECA	0.12	0.36
LAC	0.21	0.49
NA	0.17	0.43
NAfr	0.14	0.45
NRME	0.18	0.51
RMENA	0.17	0.51
SA	0.17	0.46
SSA	0.17	0.51

Source: World Inequality Database. Note: Unweighted averages across countries.

Table 10 provides results of simple regressions of mobile internet uptake on measures of inequality. Columns 1 and 2 presents results of pooled OLS estimates with year fixed effects of mobile internet on the income share of the top 1 and 10 percent of households, respectively. Column 2 shows that the income share of top 10 percent is negatively and significantly correlated with uptake. In columns 3 and 4, the inequality measures are interacted with GDP per capita to examine if the (conditional) correlation between uptake and inequality changes

[36] SSA performs worst of all regions in terms of the average income share of the top 10 percent (51.4%, relative to 51.0% for NRME and 50.7% for RMENA). At the country level, the top 10% income share measure is closest to inequality captured by the Gini index, which is unfortunately not available for all countries for 2019. According to the Gini, the top 8 countries with the highest Gini are all in SSA, led by South Africa (2014 data), except for Suriname (1999 data); other countries are Namibia, Zambia, Sao Tome and Principe, Central African Republic, Eswatini, and Mozambique. The top 10% income share rankings are similar, with Guinea-Bissau the only country in the top 10% income share and not in the top Gini rankings. The top 1% income share rankings are more different from the Gini rankings, for instance not including South Africa (12th), and including Angola, Botswana, and Malawi.

according to the level of income. The coefficients of the interaction terms are not significant. The introduction of country fixed effects in columns 5 and 6 renders the coefficient of the inequality term statistically insignificant, possibly reflecting the fact that country-level inequality measures show little variation over time.

Table 10: Conditional correlates of mobile internet uptake: Inequality (2010-2020)

Dependent variable: mobile internet uptake	(1)	(2)	(3)	(4)	(5)	(6)
Income share of top 1 percent	-0.248*		-0.112		0.00243	
	(0.127)		(0.142)		(0.0883)	
Income share of top 10 percent		-0.306***		-0.292***		-0.0541
		(0.0884)		(0.107)		(0.106)
Top 1% * gdp per capita			-0.00831			
			(0.00840)			
Top 10% * gdp per capita				-0.000578		
				(0.00358)		
Constant	-0.00541	0.106**	-0.0272	0.0994*	-0.0217	0.00360
	(0.0263)	(0.0483)	(0.0276)	(0.0566)	(0.0568)	(0.0756)
Observations	1,630	1,630	1,630	1,630	1,630	1,630
R-squared	0.806	0.815	0.807	0.815	0.853	0.853
Country FE	No	No	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of country					165	165

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Source: World Inequality Database, WDI. Note: All regressions include year fixed effects and GDP per capita (international constant PPP, from the World Development Indicators), GDP per capita squared and GDP per capita cubed. Errors are clustered around countries.

This section has highlighted that the most significant barriers to higher uptake and use include low affordability as captured by low incomes and high data prices, low capabilities as reflected by low levels of education and skills, and low levels of other complementary assets (especially electricity), and low attractiveness as reflected by low perceptions of useful content. In addition, it has reported a high degree of correlation between mobile internet uptake and the presence of network effects among subscribers. Finally, it has also shown that a negative correlation exists between income inequality and mobile internet uptake.

5. Factors Affecting Mobile Internet Supply

One of the important determinants of mobile internet uptake on the supply side is the regulatory framework. Unfortunately, the extent to which a country's regulatory authority displays a pro-competitive stance in its implementation decisions is hard to measure with accuracy.

One possible source is the regulatory data compiled by the International Telecommunications Union. (ITU).[37] It can be said that the ITU trackers are largely inspired by the regulatory framework established in the EU over the last two decades with some differences and omissions. The EU framework does not mandate privatization and the Competition Framework (CF) component of the ITU tracker favors privatization. Regulation of mobile termination rates (MTRs) has played a critical role in the development of competition in mobile services in the EU, and the ITU Tracker does not take account of MTRS. In the EU, regulation of international roaming charges has also played an important role in reducing prices of mobile calls while travelling across countries within the EU. This measure, admittedly more relevant for the creation of a regional market, does not play a role in the ITU Tracker either. Nevertheless, the general idea is that the higher is the index of a country, the closer is the regulatory framework in that country to the EU (or some similar benchmark of a high-quality regulatory framework).

Many attempts to quantify regulatory frameworks suffer from a serious drawback, which is that they mainly assess whether laws and regulations exist but not whether and how they are implemented. For example, independence of the regulatory authority may be stated in law (*de jure*) but in practice (*de facto)* the ministry may have a lot of influence over the authority's rulings. Similarly, the regulations may provide regulators with authority and procedural guidance on assessing market competition, identifying operators with Significant Market Power (SMP) and imposing obligations on them but in practice these measures may not be implemented (say, because of undue influence by operators). One expects that the de facto characteristics of the regulatory framework are at least as, if not more, critical as the de jure characteristics. The ITU indicators are mainly focused on the content of laws and regulations, and not in their implementation.

Figure 8 displays the evolution of the Overall ITU Index across regions between 2010 and2018. As of 2018, the highest values of the index appear for NA, ECA and RMENA. LAC and SA

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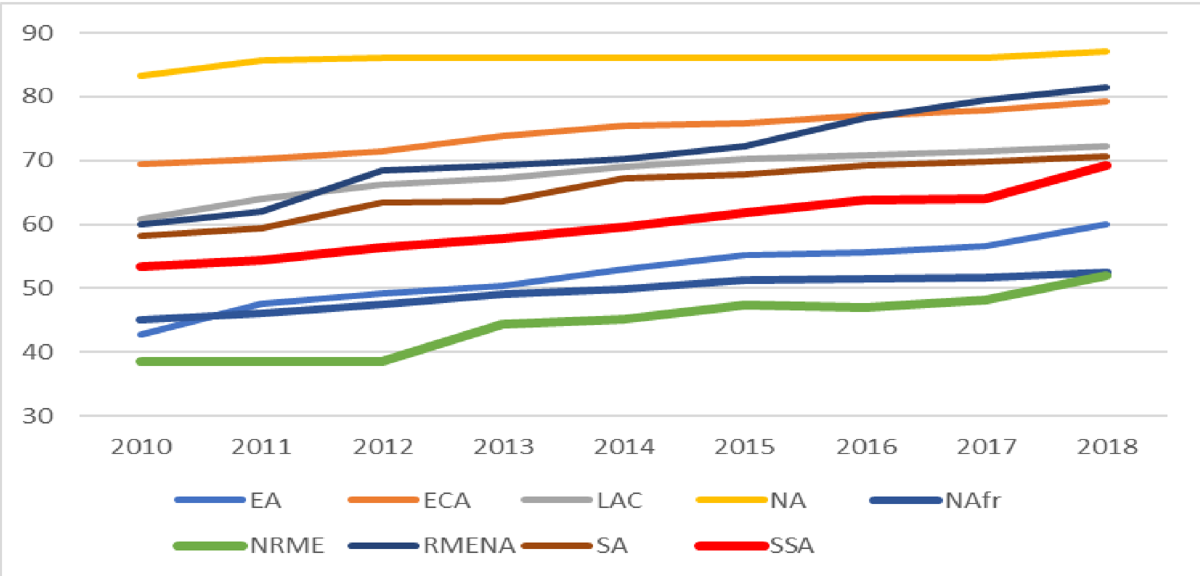
[37] The ITU regulatory Tracker data has four main components. The first, Regulatory Authority (RA), measures the existence, independence, enforcement powers and accountability of regulatory authorities as well as the existence of a competition authority. The second, Regulatory Mandate RM), evaluates the extent of the mandate of the regulatory authority, that is, areas over which it has decision making power. Included in those areas, for example, are service quality, licensing, interconnection, price regulation, spectrum management, spectrum monitoring and enforcement, universal service, broadcasting, internet content. The third component, Regulatory Regime (RR), evaluates the details of the regulatory framework. In the area of licensing, it measures how global licenses are, with general authorizations and notifications obtaining the highest grade. In the area of interconnection, whether operators are required to publish Reference Interconnection Offers and whether interconnection prices are published are measured. It measures whether infrastructure sharing is permitted and/or mandated, whether unbundled access to the local loop allowed, whether band migration is allowed and whether number portability is allowed and /and or required in fixed and mobile services. Finally, the fourth component, Competition Framework (CF), attempts to measure the degree of competition/contestability in the telecommunications markets. It measures separately the level of competition in fixed line, mobile, leased lines and international gateways (where grades range between 0 for monopoly and 2 for competition. This component also measures whether foreign participation is allowed and whether the main fixed line operator is privatized and whether the notion of operator with "Significant Market Power" exists and how it is ascertained. The four components have maximum grades of 20, 22, 30 and 28, respectively. The Overall ITU Index is the sum of four components and has a maximum grade of 100.For a detailed presentation see ITU (2020) Appendix 1 at https://itu.foleon.com/itu/global-ict-regulatory-outlook-2020/table-of-contents/overlay/appendix-1/

come next. The value of the index for SSA has increased substantially over time, from 53 in 2010 to 60 in 2018. Hence at least from a *de jure* perspective. SSA seems to have improved its regulatory framework over the last decade. As of 2018, the value of the index for SSA is higher than those for EA, NRME and NAFR. This observation needs to be qualified, however because of some observations with extremely low values of the Overall ITU Index in NAfr and NRME. Specifically, as of 2018, the value of the ITU index for both Libya and Djibouti is 4.5. When these two countries are deleted, the average value of the ITU index for NAfr becomes 76, which is higher than SSA. Djibouti's regulatory index is consistent with its very low level of mobile internet uptake (11 percent in 2018). Libya, however, is an outlier with a mobile internet uptake of 39 percent in 2018, much higher than what one would have guessed on the basis of its regulatory index. Yemen pulls down the average of the ITU index for NRME, with a level of 11 in 2018. This very low index for Yemen is consistent with its low level of mobile internet uptake in 2018 (7%). Even if Yemen is deleted, however, the average value of the Overall ITU Index for NRME (59 in 2018) is lower than that for SSA.

Figure 8: Overall ITU Index of ICT Regulation



Source: ITU

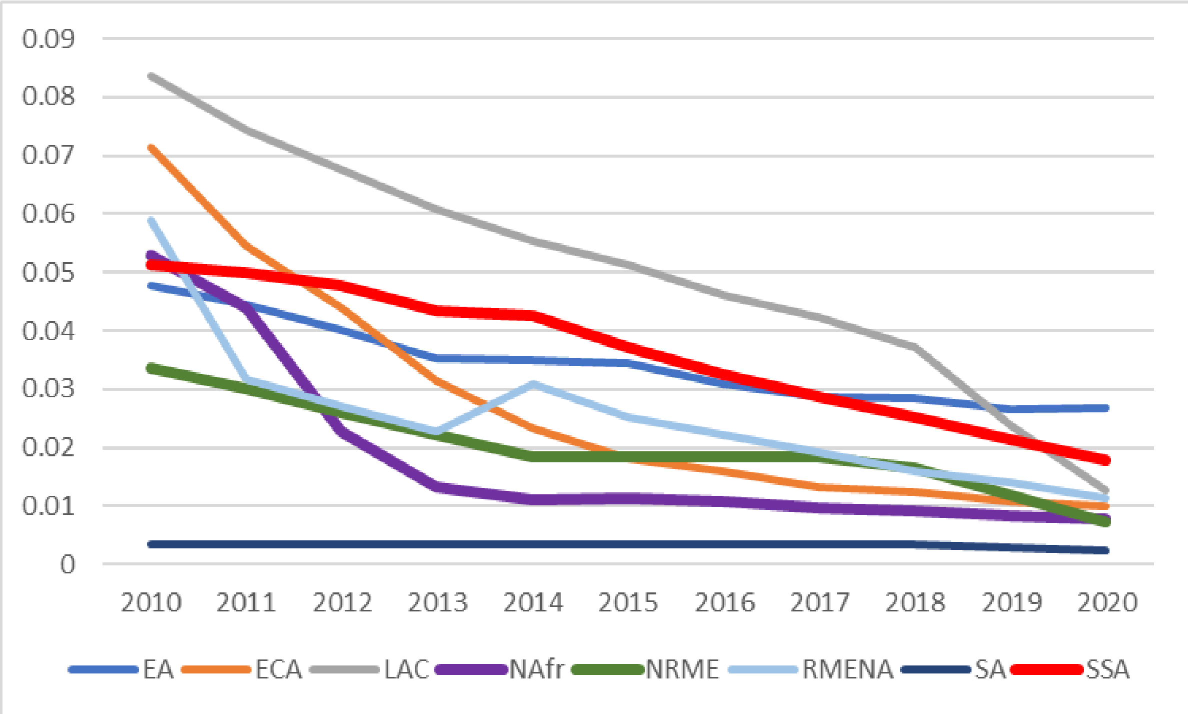
Another important indicator of regulatory stance especially in the mobile industry is the level of Mobile Termination Rates (MTRs), that is, the price operators pay to rivals for terminating a call that starts in their own network (i.e., when a subscriber of an operator calls a subscriber of another operator). Mobile call services are subject to significant "tariff mediated network externalities". That is, whenever calls made to subscribers in the same network ("on-net calls") are significantly lower than calls made to subscribers in other networks ("off-net calls") consumers will choose operators that host most of the people they are likely to call, giving operators with large established subscribers an important competitive advantage. High MTRs make it easier for operators to discriminate between off-net and on-net calls, creating a disadvantage against smaller operators and giving incumbent operators an important instrument to foreclose entry or expansion of new smaller rivals. There is overwhelming evidence that especially incumbent operators exploit these discrimination opportunities when MTRs are high. This explains why MTRs have been reduced by regulatory intervention in the European Union. There is plenty of anecdotal evidence that in developing countries, including those in SSA, NRME and NAfr, discrimination between on-net and off-net prices have been standard practice leading subscribers to the costly habit of using multiple SIM cards to take advantage of on-net discounts.

For example, Growitsch et. al. (2010) find that lower MTRs reduce retail prices and increase consumption. Genakos and Valletti (2015) find that any waterbed effect disappears as the role of mobile-to-mobile (M2M) calls grow much larger than mobile-to-fixed calls.[38] They conclude that "Since the trend in all countries is towards an increase in M2M traffic, the case for intervention is now more compelling as unintended consequences of regulation, such as the waterbed effect, are less likely to arise." This is clearly relevant for SSA, NAfr and NRME countries where most calls are made between subscribers of mobile operators. Hawthorne (2018) and Stork (2012) find that reductions in MTRs lead to reductions in retail prices in several SSA countries. Bouali argues that in Tunisia reductions in MTRs were not sufficient to stimulate reductions in price: the latter "only occurred when the Regulatory Body eliminated differential tariffs between on- and off-net calls in the retail market".

On the basis of these observations, MTRs can be seen as a critical summary indicator of a country's regulatory stance towards exercise of market power. Figure 9 shows the evolution of average MTRs by region. The figure shows that while MTRs have declined in all regions, as of 2020 sizeable differences across regions still exist. MTRs in East Asia are highest (2.6 cents), followed by SSA (2.1 cents). There are wide variations across countries. In the SSA, in 3 countries (Congo, Capo Verde, and Sierra Leone), MTRs in 2020 are extremely high, above 5 US cents per minute. It is below 1 cent per minute in 9 countries (out of 32 for which data exist in 2020). Variability is much less in the NAfr and NRME regions, partly reflecting absence of data. In the NAfr region, data exists only for Morocco, Algeria and Tunisia, the average of which is reflected in Figure 8. In the case of NRME data on MTR exists only for Jordan.

[38] The waterbed effect refers to the possibility that a reduction in MTRs, while reducing the prices of fixed to mobile calls, may result in higher rather than lower mobile to mobile retail prices.

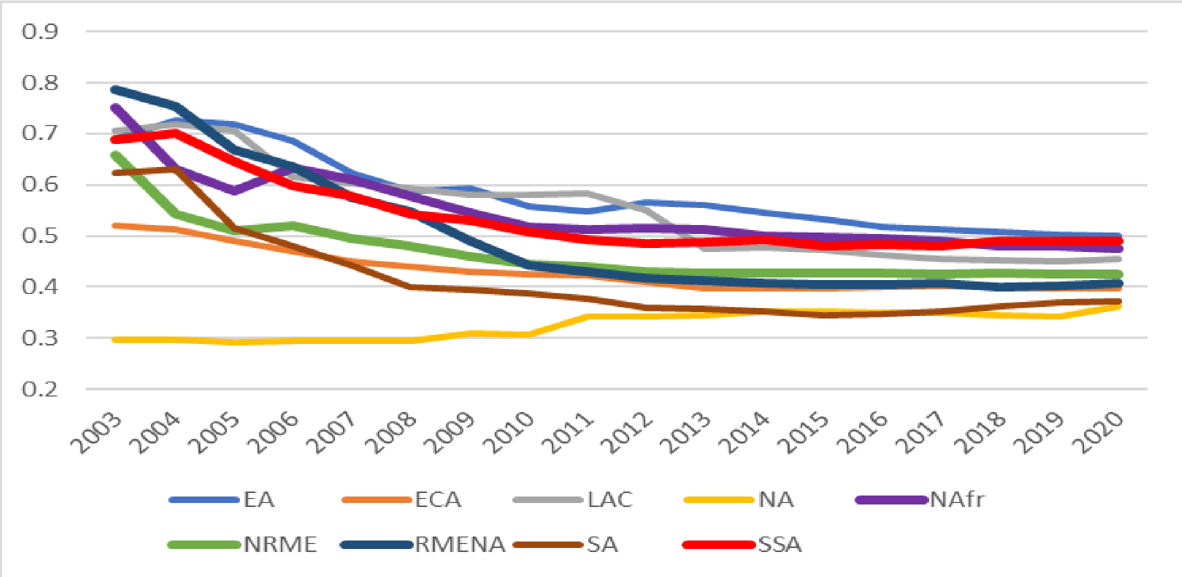
Figure 9: Average Mobile Termination Rates by Region (US$ per min, 2010-2020)



Source: Telegeography. Annual averages over countries.

Another related conditional correlate of affordability and uptake affecting mobile internet supply is the degree of concentration in the mobile markets. It is generally believed that high concentration is an indicator of low competitive pressures on operators with large market share, ability to exercise market power, and lack of pressure to offer high quality services at low process. This is typically measured by the Herfindahl Hirschman Index (HHI), which is the sum of squared market shares, and varies between 1 (full monopoly) and close to zero if there are many firms each with very small market shares. As shown in Figure 10, there is a marked decline in HHI in all regions except for NA, which has increased over time due to consolidations but is still very low. Evolution of the HHI index in SSA is interesting. It was very high in the early 2000s. It then declined until 2012 and then remained steady and even increased slightly in 2018-2020. So even though the HHI in SSA was below NAfr and LAC up until 2010 or so, by 2020 SSA is the region with highest HHI, along with EA (0.49 in SSA and 0.50 in SA). This increase in SSA seems to be partly driven by operator exits, as discussed in the next section.

Figure 10: Evolution of concentration in mobile markets



Source: Telegeography. Note: Herfindahl-Hirschman index calculated from operators' share of numbers of subscribers.

Table 9 provides some evidence on the conditional correlations between mobile internet uptake and the regulatory and market structure variables reviewed above. The dependent variable is again unique mobile internet subscriptions per population. All regressions include controls for the level of income (GDP per capita, GDP per capita squared and GDP per capita cubed) and year fixed effects. Columns 1-3 report results of pooled OLS regressions. Column 1 shows that unique mobile internet uptake is negatively correlated with MTRs and the coefficient is statistically significant. Column 2 shows that mobile internet uptake is also negatively and significantly corelated with concentration. Column 3 shows that mobile internet uptake is positively correlated with the overall ITU index. Columns 4-6 show the results when country fixed effects are included in the analysis. MTR and HHI continue to be negatively and statistically significantly correlated with mobile internet uptake. The coefficient of the ITU index remains positive but is no longer significant. The findings suggest that supply-side factors as captured by better MTR regulation implementation in particular, as well as lower market concentration and a better overall ITU regulatory framework are significant associates of higher uptake; lower uptake in SSA is associated with missing MTR rules, higher market concentration and lower quality regulatory frameworks. In addition, the higher coefficient of determination (R-squared) values in these regressions, in particular MTR rules with and R-squared of 83% in the pooled OLS regression, again relative to those where only per-capita income is included (71% as reported in Table 1), suggest that regulatory variables have additional explanatory power beyond income as an important set of factors associated with uptake.

Table 11: Conditional correlates of mobile internet uptake: Regulatory variables (2010-2018)

Dependent variable: mobile internet uptake	(1)	(2)	(3)	(4)	(5)	(6)
MTR_usd	-0.819**			-0.757***		
	(0.326)			(0.255)		
HHI Index TeleG data		-0.292***			-0.159***	
		(0.0465)			(0.0439)	
Overall ITU index			0.00202***			0.000247
			(0.000443)			(0.000477)
Constant	-0.00896	0.106***	-0.145***	0.145*	0.0904	-0.0291
	(0.0263)	(0.0262)	(0.0236)	(0.0780)	(0.0658)	(0.0702)
Observations	1,259	2,033	1,615	1,259	2,033	1,615
R-squared	0.835	0.765	0.759	0.861	0.829	0.807
Country FE	No	No	No	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of country				128	190	184

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Source: Telegeography, GSMA, WDI. Note: The dependent variable is unique mobile internet uptake. All regressions include controls for GDP per capita, GDP per capita squared and GDP per capita cubed (international constant PPP). Errors are clustered around countries. MTR data is available for the years 2010-2020 but with missing values in the earlier years. The HHI index is calculated from operator market shares in terms of number of subscribers.

6. The supply side: competition-related case studies

The analysis of factors affecting mobile internet supply suggests that market concentration is an important conditional correlate of uptake. Concentration in mobile markets is the outcome of the interaction of a number of factors, including policy and regulatory decisions on the nature and timing of privatization and new entry, on the provision of licenses and the number of permitted operators, and on the allocation of critical resources such as spectrum, as well as the strategic behavior of operators in the market. In this section we explore a few country case studies to develop a deeper understating of these interactions.

Markets for mobile services are characterized by substantial first mover advantages. Operators who enter first can create a loyal subscriber base and later entrants can find it difficult to build market share. Existence of economies of scale and scope, as well network externalities that can be strategically exploited by incumbents play an important role in the creation and consolidation of first mover advantages. In particular, especially when MTRs are high, incumbents can exploit network externalities by creating a gap between on-net and off-net prices. For subscribers, such price discrimination makes it attractive to move to operators who serve most of the people they call. That, in turn, allows incumbent operators with already established subscriber bases to maintain their loyalty and makes it easier to attract new subscribers. When MTRs are high, discriminating between on-net and off-net prices becomes easier. In addition to these first mover advantages arising naturally from the characteristics of these technologies and markets, incumbents are also often among those enterprises most favored by political authorities, allowing them access to policies that may further consolidate their first mover advantages and more effectively discriminate against rivals and potential new entrants.

Therefore, the evolution of market structure may be closely affected by the market development strategy followed by policy and regulatory authorities. The potential existence of first mover advantages, in particular the ability of incumbents to foreclose entry or expansion, and weaknesses in the regulatory environment that can be taken advantage of by politically favored incumbents, can delay the development of competition and attendant producer and consumer benefits from developing in mobile markets.

The likelihood and speed through which competition develops is likely to depend on the following:

- Whether initial licenses are given to a single or multiple operators, and the time lag with which new entrants are allowed.
- Whether the incumbent (often state owned) fixed operator obtains a license before potential competitors
- Whether the state-owned incumbent is privatized before the regulatory framework is established
- Whether mobile number portability is introduced early and how effectively it is implemented
- Whether and how effectively mobile termination rates are regulated
- Whether the regulator adopts measures limiting off-net on-net price discrimination
- Whether infrastructure sharing is allowed.

The cases of Ghana, Senegal, Kenya, Benin, and Tunisia examined in this section provide illustrations and insights about how different market development strategies may have affected market outcomes. Table 10 provides some key indicators for the case studies. It shows that in terms of both prices and uptake, Tunisia performs the best and Benin is the last. In terms of uptake, Ghana seems to be the second-best performer, ahead of Kenya and Senegal. The table shows that Tunisia has the lowest concentration, followed by Senegal and Ghana. MTR is lowest for Tunisia. The MTR figure for Ghana refers to the year 2018, hence the current level may be lower. In terms of prices as well, Tunisia is the best performer. Senegal has low prices in USD. However, the ITU data may be wrong in this case because it shows a reduction from about 32 USD in 2018 and 30 USD in 2019 to 3 USD in 2020, which is highly unlikely.

Table 12: Key indicators for the case studies (2020)

					Prices					
	Unique mobile internet uptake	Unique mobile uptake	MTR usd	Cocentration (HHI)	mobile data & voice low GNIpc	mobile data & voice high GNIpc	mobile data & voice low PPP	mobile data & voice high PPP	mobile data & voice low USD	mobile data & voice high USD
Benin	0.28	0.48	0.0174	0.51	6.93	14.42	19.43	40.42	7.06	14.70
Ghana	0.38	0.56	0.0180	0.41	1.92	4.19	9.28	20.22	3.22	7.02
Kenya	0.31	0.53	0.0093	0.51	4.75	7.12	16.90	25.31	6.71	10.05
Senegal	0.33	0.52	0.0063	0.41	2.76	2.76	8.13	8.13	3.28	3.28
Tunisia	0.60	0.77	0.0043	0.35	0.59	1.77	5.64	16.93	1.63	4.88

Note: all values refer to the year 2020, except for MTR in Ghana, which is for the year 2018.

Starting with Ghana, it allowed entry into the mobile industry with the vision of creating a competitive multi-operator market. The first entry, by Mobitel, occurred in 1992. A second mobile operator, Celltel, began operations in 1995 (Haggarty et. al., 2003, p. 20). These entrants did not pay anything to obtain their licenses. The third entrant, Scancom (Spacefon), paid the government US$500,000 to enter the market and began operations in 1996.

By 2002, Celltell and Mobitel, the two initial entrants, were reported to be "on the edge of dissolution" (Haggarty et al , p. 25). Of the three operators, Scancom became the largest. Scancom was rebranded as Areeba in 2005 before being acquired by MTN Group in May 2006, and subsequently rebranded as MTN Ghana in June 2007.

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Further licenses were awarded in the 2000s: Vodafone Ghana (then GT One Touch) obtained a license in 2000, and Millicom (later Tigo) was issued a license by the NCA in 2004. In 2008 a fixed line operator Westel was taken over by Kuwaiti Zain and started to offer mobile services in that year. That operator became Airtel in 2010 when it was taken over by India´s airtel. Again in 2008, Nigerian privately owned telecoms operator Globacom, was announced the winner of a new mobile concession after a 'beauty contest' tender fought with ten other competitors. Following a series of regulatory issues, GloMobile eventually launched as the country's sixth mobile network at the end of April 2012, almost three years after winning its concession. So by 2012 there were 6 operators: Celltell (Kasapa), Airtel, Millicom, Vodafone, GloMobile, and MTN.

For 3G services, 3G authorizations were issued by the NCA to GSM operators Airtel, Tigo, Vodafone Ghana and GloMobile in 2008, with MTN Ghana given its 3G concession in January 2009. The licenses are initially valid for 15 years and all 3G licenses are due for renewal in January 2024.

As of 2021, according to TeleG (2021) two operators have been awarded spectrum for 4G services, namely Vodafone Ghana and MTN Ghana.

There have been two critical developments in the last few years. The first is the merger of the country's second and third largest operators, Millicom subsidiary Tigo and Bharti Airtel's Airtel in 2017. The resulting company AirtelTigo was sold to the government of Ghana in October 2020, after the owners declared their intention to leave the country. It has been reported that the company was acquired for $1.00. It was also reported that AirtelTigo was losing money.[39] The other important development was the termination of Celltell's (brand name

[39] https://africa.businessinsider.com/local/markets/airtel-finally-exits-ghana-sells-business-to-the-ghanaian-government/8712dbx

Kasapa) license. The reason for the termination was reported as default of payment of annual regulatory fees since 2014, inability to offer licensed services and coverage obligations since 2014, and engagement in anticompetitive practices by terminating/transiting international traffic as domestic traffic on other networks (SIMBOX fraud).[40] Kasapa's share was around 3-4 percent in the mid-2000s and lower than 1 percent in most of the last decade.

These developments had a significant effect on Ghana's market structure, leading to a significant increase in concentration, from about 0.30 in 2015 to 0.41 in 2020. This was mainly due to the increase in the market share of MTN Ghana from around 47 percent in March 2018 (having declined from about 65 in 2004) to about 57 percent by December 2020. In June 2020 the regulatory authority designated MTN Ghana as an operator with significant market power. The obligations imposed on MTN were quite severe, including asymmetric MTR charges, and prohibition of discrimination between on-net and off-net charges. Mobile number portability was implemented as early as 2010. TeleG data on MTRs does not include Ghana. However, TeleG (2021) reports that in 2017 MTR was set at USD 0.018. While not very high there were still quite a few countries in the SSA with lower rates (specifically, 13th lowest among SSA countries in that year).

In Senegal, the developments were very different. An initial license for 2G services was granted to the incumbent fixed line operator Sonatel in 1996. The second operator, Millicom-backed Tigo Senegal was licensed in 1998 and started operations in April 1999. The third operator, Sudanese owned Expresso Telecom, was allowed to enter in 2007. In 2007, Orange took a controlling stake in Sonatel Mobile. So, by 2007 there were 3 operators, namely Orange, Tigo and Expresso. Mobile number portability was only introduced in 2015. First mover advantage in the case of Senegal is apparent in the high market share that Orange has been able to maintain, with its market share remaining at above 76% until 2012 and declining to 55 percent by 2020.

So while the market share of the largest operator first declined and then increased in Ghana (the latter mainly due to the poor performance of its main competitors), in the case of Senegal Orange's market share never went below 50%. The fact that mobile number portability (MNP) was not introduced until 2015 was partly responsible for the large market share of Sonatel. More importantly, Sonatel effectively controlled access to the main international gateway, which was not effectively regulated. Also, Sonatel was assigned radio spectrum ahead of its competitors in a move by the government sidelining the regulator (World Bank, 2018). Hence not only did the regulatory and policy framework did not counterbalance Sonatel's first mover advantages, they actually reinforced them to the detriment of development of competition.

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[40] https://newsghana.com.gh/license-of-expresso-revoked-nca/?__cf_chl_jschl_tk__=pmd_9db64a87fe0837773538dcc4ab52951518fc7d77-1627607052-0-gqNtZGzNAfijcnBszQi6

In the case of Kenya as well, the first mobile license was granted to the incumbent fixed operator; Safaricom was formed in 1997 as a fully owned subsidiary of the state-owned operator Telkom Kenya. The entry of the second operator occurred only in January 2000 when Kenya's second GSM-900 license was awarded to Kencell (which was subsequently renamed Celtel Kenya in 2004, Zain Kenya in August 2008, and Airtel Kenya in late 2010). Then, in May 2000, Vodafone Group PLC of the United Kingdom acquired a 40% stake and management responsibility of Safaricom. Plans to introduce a third operator license were announced in 2003. The winner was announced in December 2003 but due to legal challenges from competitors, the granting of the license and provision of services were delayed. The third player, Econet, later called Essar Telekom only started operations in 2009. A fourth player was introduced in 2007 when the fixed line incumbent handed its shares in Safaricom to the government and 51 percent of its share was given to Orange. Orange later divested in 2017. In 2014, Essar Telekom was sold to Airtel and Safaricom, reducing the number of operators to 3. A fourth operator, Jamii Telecom, entered in 2017.

Safaricom's dominance in the Kenyan mobile market was never challenged. In 2003 its market share in terms of numbers of subscribers was 64%, by 2007 it increased to 82 percent, mainly capturing market share from Airtel, whose market share decreased from 36 to 18 in the same period. In the last decade, Safaricom's market share was between 65-70 percent, that of Airtel between 17-28 percent. Telkom Kenya's market share increased to 12 percent in 2012 but was down to 6% in 2020.

In 2004, Kenya's Communications Authority (CA) announced that MNP would be introduced in 2005. However, it was not implemented due to "operators complaining about the high costs involved with setting up the system". It was finally implemented in 2011. MTR have been historically high, at 4 cents between 2010-2013, around 2 cents 2015-16, but were down to 0.6 cents in 2020. Political influence partly explains the delays in the reduction of MTRs: the CA reduced the MTR to 2.21 KES in 2010, which led Airtel to reduce its retail prices and in turn generated a price war. Then, "Following heavy pressure from Safaricom, then-president Mwai Kibaki suspended the reduction of termination charges in June 2011; the rates had been expected to drop from KES2.21 to KES1.44 in July 2011, potentially setting the stage for a new round of price cuts." (Telegeography, 2021) A 4G license was awarded to Safaricom in 2014, whereby the "regulator included infrastructure sharing as a pre-condition for licensing Safaricom's 4G rollout, and as such the cellco is required to cede at least 30% of the network's capacity to rivals to be shared on a commercial basis (although as of November 2020 this requirement has not been enforced)." (TeleG 2021). The award of the license was criticized due to the absence of an open bidding process.

In May 2016, the CA appointed Analysys Mason to conduct a study on competition in the telecom sector. The draft report, which was leaked to the local press in early 2017, proposed that Safaricom be broken up to reduce its dominance. The study recommended the separation of Safaricom's core telecoms operations from its mobile financial service M-PESA (see below), as well as the imposition of retail price controls and infrastructure sharing. In February 2018, the CA invited stakeholder feedback on the competition study, at which date it was reported that the revised report would not lead to the breakup of Safaricom. Additional changes to the initial document included a reduction in the number of counties where operators would be required to provide national roaming (and where Safaricom would be required to share its towers) from 14 to seven.

Safaricom, of course, is well known for the introduction of the mobile money services M-PESA launched in 2007. It allowed customers without bank accounts to deposit and withdraw cash, transfer money via SMS, and top up airtime. Cash is paid in and withdrawn at specified M-PESA agents, including Safaricom dealerships, supermarkets, shops, and petrol stations. International money transfer was added in 2011. M-Shwari, launched in 2012 jointly by Safaricom and the Commercial Bank of Africa, allows users to save, earn interest and borrow money using their mobile phones, while Lipa na M-PESA was introduced in 2013, enabling customers to pay for goods and services. An overdraft facility Fuliza was launched in 2019. Airtel has its own mobile money services, Airtel Money. Telkom had the Orange Money service. This was discontinued in 2017 and Telkom introduced a new brand, T-kash in 2018. Mobile money interoperability between Airtel, Safaricom and Telkom was established in 2018.

The case of Benin is interesting because it also entailed initial players that were distinct from the incumbent state-owned operator. The mobile market in Benin started in 2000 with Benincell (or MTN Benin) and Moov (UAE/Morocco). Local investment venture Bell Benin (BBCOM) entered the sector in December 2003, but its license was cancelled on 2 August 2017 having been non-operational for several months. In 2008 GloMobile entered as the third operator. In the year 2000 state owned Benin Telekom's subsidiary was also launched. But that company was terminated by the government in 2017 after experiencing financial difficulties. The license of GloMobile was terminated by the decision of the regulator in 2017. Its license was up for renewal in 2017, and negotiations for its renewal failed and the regulator ordered all GloMobile subscribers to move to Moov within three months or lose their subscription. It has been reported that the regulator wanted to impose service quality conditions that the operator did not accept.[41] The market share of GloMobile in 2016 was about 12 percent, down from 19 percent in 2014.

So effectively Benin has two mobile network operators. In 2021 the government launched a new tender for a third operator, and it was understood that the tender would be granted to a state owned company Beninese Digital Infrastructure Company (SBIN, Societe Beninoise d'Infrastructures Numeriques) with the objective that this company would become a major operator in five years to "shake the market".[42] Benin's finance ministry and Ministry of Digital & Digitalization have been instructed to oversee "a successful transformation of SBIN into a

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[41] https://www.premiumtimesng.com/business/business-news/253811-withdrew-globacoms-license-benin-republic.html. Another news piece identified increase in the cost of the license as the reason for the failure of negotiation. See https://www.reuters.com/article/benin-telecoms-idUSL8N1OJ5M3

[42] https://developingtelecoms.com/telecom-business/operator-news/9350-benin-to-shake-up-duopoly-with-new-state-operator.html

global telecommunications operator" by the Council of Ministers (ibid). Reportedly, a shortlist of management companies, including Tata communications and Sonatel, has been drawn. The contract was given to Sonatel.[43] Of concern, MTR remains quite high, even in 2020 (above USD 1 cent).

Tunisia is interesting because it started with a heavily concentrated mobile industry which eventually became more competitive through regulatory policy. In Tunisia, the first license in mobile telephone services was granted to the state-owned incumbent operator Tunisie Telecom (TT), which started to provide services in 1998. A second license was given to Orascom Telecom Tunisie (Ooredoo) in 2002. The pair shared legal exclusivity on the market until 2004, but a third license was granted much later, in 2009, following a tender that was won by a consortium led by Orange Telekom. All three operators also bid for and obtained 4G spectrum in 2015.

Despite the first mover advantage of the incumbent as well as of the second entrant, and even though the number of players remained stable, Tunisia displayed some remarkable market dynamics and reshuffling of market shares in the last two decades. In 2003, the market share of TT was 74 percent and that of Ooredoo was 26 percent. By 2009, the market share of TT was reduced to 47 percent. The third entrant, Orange was also able to capture market share in a steady manner so that by 2020 the market share of Ooredoo, TT and Orange were 43, 34 and 24 percent respectively. The HHI was reduced from 0.50 in 2008 to 0.35 by 2020. A critical driver of the change in the market structure was the actions of the regulator. Initially, the National Telecommunications Authority (Instance Nationale des Télécommunications, INT) symmetrically reduced MTR in a step-like fashion between 2006-2009. This action did not result in a significant decrease in retail prices of the incumbent duopoly.[44] Following the entry of the third operator, in 2010 the INT implemented asymmetric MTRs, offering higher MTRs to the new entrant relative to the incumbent duopoly. This policy continued until 2014 when the INT decided that asymmetric rates were no longer necessary as the new entrant had successfully established a customer base of its own.[45] Starting in 2014, INT returned to a policy of reducing MTRs in a symmetric manner. This enabled the new entrant to reduce off-net prices significantly, followed soon by the incumbents. However, reductions occurred only on packages with calls for 15 days, after which the subscriber had to refill by a fixed (and high) amount, which was very costly for subscribers except for heavy users. In other words, the price war was limited and tariff discrimination continued. Finally, INT ordered that off-net and on-net prices needed to be equalized before January 2016. This led to a genuine price war and a rapid increase in subscriptions. Between 2016 and 2020 the unique mobile internet uptake increased from 45 to 69 percent. Thus, it has been argued that the reduction in MTR was

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[43] https://developingtelecoms.com/telecom-business/operator-news/10911-benin-awards-management-contract-for-state-operator-sbin-to-sonatel.html

[44] Bouali suggests that the incumbent duopoly may have

[45] The INT was not alone in trying to push incumbents towards a more competitive stance. In 2011 the Competition Authority fined the two incumbents for differentiating on-net and off-net tariffs (Bouali, 2017).

insufficient to spur competition, and an elimination of on-net off-net price discrimination was required (Bouali, 2017).

The main lesson suggested by this set of illustrative case studies is that first mover advantages are potentially very strong in the mobile industry. Granting first licenses to the incumbent operator and delaying further entry are likely to reduce competition and result in high concentration that become harder to curtail in the future. At the same time, the Tunisia example shows that even in such cases, high concentration can be reduced by active regulatory policy that curtails the incumbents' ability to foreclose entry and expansion of new entrants, even when the number of players remains stable. In addition, the apparently high incidence of exit also seems to reflect the relatively difficult and turbulent investment environment. The case of Ghana suggests that a large number of players is not a guarantee for competitive market outcomes.

The high incidence of exit in the cases described above is interesting. It turns out that high incidence of exit in the SSA region is not limited to the cases described above. Table 11 provides some statistics regarding incidence of exits between 2003 and 2020, as reported by Telegeography. The numbers exclude disappearance of operators due to mergers or acquisitions, and only reflect "pure" exits. Out of 80 exits that occurred worldwide between 2003-2020, 36 occurred in Africa. In order to provide control for scale, the table reports also exits per population. SSA displays by far the largest number of exits by total population as well as by population of people 15 years old and above. The last column shows that the median maximum market share of exiting firms[46] in SSA was 9 percent, much higher than the rest of the regions. So, these were exits of firms that at one point had substantial market share.

Table 13: Cumulative number of exits per region, 2003-2020

Region	No. of MNO exits	No. of MNO exits per million people	No. of MNO exits per million 15+ people	Mean maximum market share of exiting firms	Median maximum market share of exiting firms
East Asia & Pacific	8	0.003	0.004	0.2065	0.0197
Europe & Central Asia	17	0.018	0.023	0.1114	0.0177
Latin America & Caribbean	6	0.009	0.012	0.1268	0.0283
Middle East & North Africa	5	0.011	0.015	0.0244	0.0222
North America	0	0	0		
South Asia	8	0.004	0.006	0.0644	0.0312
Sub-Saharan Africa	36	0.032	0.055	0.1687	0.0905
Total	80	0.010	0.014	0.1377	0.0448

Source: Telegeography. Note: Exit numbers do not include disappearances of operators due to mergers or acquisitions.

[46] This is the median of maximum market share of exiting firms in the years before they exited.

A high incidence of exit could be a sign of efficient markets. After all, the market mechanism is often considered to be working well when it induces the exit of inefficient firms. However, a high incidence of exits could also be a reflection of "tough" market conditions, excessive turbulence, lower access to finance, or even political influence. In any case it may be useful to examine whether exits are correlated at all with uptake. Table 12 reports some simple OLS regressions of mobile internet uptake on some indicators of exit. The first column reports the result of a regression of uptake in 2020 on cumulative number of exits between 2003-2020. The coefficient on the number of exits is negative and significant. The second column does the same but controls for per capita GDP (and its square). The coefficient of the exit variable becomes insignificant, suggesting that perhaps number of exits is closely (negatively) correlated with incomes, namely that poorer countries exhibit higher exits (the correlation coefficient between GDP per capita in 2020 and cumulative exists is -0.28 and significant). In the third column, uptake in 2020 is regressed on the maximum market share of exited firms. The coefficient is negative and significant. The fourth column does the same, controlling for GDP per capita, and the coefficient remains negative and significant. This suggests that countries where operators that at one point had non-negligible market share and exited also are characterized by relatively lower uptake in 2020. It would be interesting to compare these figures with what happened in Europe in the 1990s. Unfortunately, data for the 1990s are not available. In any case, the findings suggest that SSA may have a "tougher" business environment for operators, or that selection of operators into the market may not have been efficient in the first place. Further analysis of the dynamics behind exits is warranted.

Table 14: Too many exits in SSA?

Dependent Variable: mobile internet uptake	(1)	(2)	(3)	(4)
No. of exits	-0.0640***	0.00514		
	(0.0139)	(0.00801)		
Max. market share of exited firms			-0.520***	-0.134
			(0.148)	(0.0856)
Constant	0.503***	0.210***	0.497***	0.228***
	(0.0159)	(0.0176)	(0.0149)	(0.0181)
Observations	214	178	214	178
R-squared	0.058	0.756	0.076	0.759

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Source: GSMA, Telegeography, WDI. Note: the dependent variable is unique mobile internet uptake in 2020. Control for per capita GDP includes GDP per capita (international PPP) its square and cube.

7. Which conditional correlates of internet uptake are more important? a quantitative assessment

We have examined various individual factors that are correlated with mobile internet uptake on the demand and supply sides of the mobile services industry. This section provides an assessment of the relative quantitative importance of the different factors. The analysis has serious limitations since it cannot say anything about causality. It is further restricted by availability of data: all the relevant data are jointly available for only one year, namely 2018. With these qualifications, we still think some initial assessment of relative quantitative importance is useful.

Table 15 presents the results of simple regressions of unique mobile internet uptake on selected previously-explored indicators of skills, regulatory stance, inequality, access to electricity, income and prices. For skills we use learning adjusted years of schooling and harmonized test scores. Similarly, regulatory stance is captured by the Herfindahl Hirschman Index (HHI) and mobile termination rates (MTR). Prices are captured by two indicators compiled by ITU: prices of low and high use mobile voice and data packages, expressed in purchasing power parity. To compare the quantitative importance of the different factors, all variables have been standardized and marginal effects of the variables are reported, showing how many standard deviations mobile internet uptake changes when the right-hand side variables each increase by 1 standard deviation. The stars refer to levels of statistical significance. All regressors enter the regression equations in a linear fashion, except for GDP per capita, for which a squared term is also used.

Table 15: Joint conditional correlates of mobile internet uptake: Average marginal effects (2018)

Dependent variable: unique mobile interne	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Learning-Adjusted Years of Schooling	0.250***		0.259***		0.158*		0.183**	
	(0.080)		(0.079)		(0.089)		(0.089)	
Harmonized Test Scores		0.176***		0.182***		0.099		0.105
		(0.063)		(0.063)		(0.064)		(0.066)
HHI Index TeleG data	-0.114**	-0.115***	-0.118**	-0.120***				
	(0.046)	(0.043)	(0.048)	(0.045)				
MTR_usd					0.040	0.041	0.028	0.029
					(0.026)	(0.026)	(0.028)	(0.028)
PPP mobiledatavoicelow	-0.040	-0.063*			-0.102**	-0.120***		
	(0.034)	(0.032)			(0.044)	(0.042)		
PPP mobiledatavoicehigh			-0.021	-0.046			-0.037	-0.054*
			(0.030)	(0.029)			(0.031)	(0.031)
income share of top 10 percent	-0.019	-0.023	-0.020	-0.022	0.034	0.031	0.018	0.012
	(0.037)	(0.036)	(0.037)	(0.037)	(0.039)	(0.039)	(0.042)	(0.043)
Access to electricity (% of population)	0.162***	0.215***	0.160***	0.212***	0.183***	0.218***	0.193***	0.236***
	(0.045)	(0.039)	(0.044)	(0.039)	(0.050)	(0.040)	(0.051)	(0.043)
GDP Per Capita, constant PPP	0.640***	0.695***	0.626***	0.681***	0.801***	0.846***	0.747***	0.806***
	(0.081)	(0.074)	(0.079)	(0.072)	(0.084)	(0.075)	(0.082)	(0.074)
Observations	137	137	137	137	103	103	103	103

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Source: GSMA, Telegeography, HCI, WDI. Note: The regressions cover the year 2018 and use standardized variables, equal to the original value minus the mean divided by the standard deviation. All regressors enter the regression equations in a linear fashion, except for GDP per capita (constant PPP), for which a squared term is also used. The table reports average marginal effects of the standardized variables, that is, how many standard deviations mobile internet uptake changes when each right-hand side variable increases by 1 standard deviation.

In the first four columns, HHI is used as the variable capturing regulatory stance, whereas MTR is used in columns 5-8. MTR data exist for a smaller number of countries. It turns out that HHI is significant and positive whereas MTR is not significant. As seen from the case studies presented in the previous section, HHI is likely to be closely affected by the way in which the mobile market is liberalized and new entry is regulated. The fact that HHI is significant but MTR is not may reflect both the lower number of observations in the case of MTR, but it may also suggest that regulatory actions and timing, including how they affect the nature and sequencing of entry may be more important than policies specially focusing on MTRs. We conjecture that results reported in columns 1-4 are more informative about the relative quantitative importance of the conditional correlates of mobile internet uptake.

These results show that quantitatively the most important variable associated with internet uptake is GDP per capita: one standard deviation increase in GDP per capita is associated with a 0.6-0.8 standard deviation increase in mobile internet uptake. Next in terms of relative importance come skills and electricity. In the case of skills, a one standard deviation increase in learning-adjusted years of schooling is associated with a 0.25 standard deviation increase in mobile internet uptake in columns 1 and 3. In columns 2 and 4, a one standard deviation increase in harmonized test scores is associated with a 0.18 standard deviation increase in mobile internet uptake. A one standard deviation increase in access to electricity is associated with a 0.16-0.22 standard deviation increase in mobile internet uptake. Next is regulatory stance: columns 1-4 show that a one standard deviation decrease in HHI is associated with 0.11-0.12 standard deviation increase in mobile internet uptake. Results also suggest that data prices are quantitatively less important than income, skills, electricity or regulatory stance. Columns 1-4 show that the marginal effects of the price variables vary between -0.2 and -0.6 but are not statistically significant.

We reiterate that the analysis pertains to correlations and not to causality. Furthermore, a simple cross-country regression analysis of drivers alone is insufficient to provide insights about the extent to which different constraints are jointly binding. For example, would an increase in access to electricity by itself result in higher mobile internet uptake? The answer depends on the degree of substitutability between access to electricity and, for example, skills. It could be that higher access to electricity would enable higher uptake but only to a specific threshold at which skills would become binding. Without more detailed analysis with household and enterprise panel data, it is difficult to speculate.

8. Conclusions: towards appropriate policies supporting greater uptake and use

One of the important findings of this paper is that in SSA and to some extent in NAfr and NRME regions (especially in those countries where uptake is lower than regional averages), the main constraint to the benefits arising from broader digitization lies not in internet coverage but in too little uptake and use of internet and the additional range of productive technologies that are enabled by internet. This finding, in turn, explains the remainder of the paper’s focus on associates of internet uptake. Uptake is constrained by factors related both to the demand and supply sides.

In low-income countries, adoption of mobile internet is constrained by the complex interaction of several key drivers. This paper has shown that especially in SSA but to an important extent in NAfr and NRME regions as well, countries lag behind in key variables that are highly correlated with adoption of mobile internet. These include, besides income and prices, education and skills, and in the case of SSA, access to electricity. On the demand side, the most important barriers to uptake and use include low affordability as captured by low incomes, followed by low capabilities as reflected in low levels of education and skills, and low levels of other complementary assets (especially electricity). High data prices and low attractiveness as reflected in low perceptions of useful content also appear as being important associates on their own though less important based on a joint assessment—subject to the proviso that objective measures of attractiveness in terms of useful content are not available. These factors, in turn, make it difficult to generate consumption-side network externalities that further encourage uptake: for many of the digital services enabled by internet, the benefits that a consumer gets from internet increase with the level of overall uptake, which is precluded by affordability, capabilities and attractiveness constraints. It is highly likely that the degree of substitutability between some of these factors is not very high, at least in the short run. In other words, increasing affordability through income transfers enabling higher disposable income or through targeted subsidies to low-income people for mobile phone purchases and data packages, for example, without concomitant increases in capabilities such as higher quality education and skills, complementary infrastructure such as affordable electricity, and attractiveness linked to useful content, may not greatly increase the likelihood of adoption and more intensive productive use. The main consequence of this situation is continued low ability to pay and low willingness to use internet and its enabled digital services, hence relatively low demand facing network operators.

On the supply side, given levels of demand, the offered variety, quality, and price of internet and enabled digital services critically depend on the level of market competition. The level of competition, in turn, depends critically on the policy and regulatory frameworks that govern the evolution of these markets. This paper finds evidence of a significant negative correlation between uptake and the degree of concentration in the mobile market as well as the key regulatory variable of MTRs. When explored in a joint regression framework together with selected demand-side variables, market concentration remains significant while MTRs do not, plausibly suggesting that regulatory actions and timing, including how they affect the nature and sequencing of entry may be more important than policies specially focusing on MTRs. SSA countries where operators that at one point had non-negligible market share and exited also are characterized by relatively lower uptake, possibly linked to lack of competition in early stages allowing the entry of less efficient operators. A more detailed exploration of country case studies reveals that the degree of concentration and market power are closely related to the evolution of regulatory policy, including whether a pro-competitive stance was displayed when the market was initially opened to investment. The case studies also reveal that even with a relatively anti-competitive history of market dynamics in initial years, regulators have important instruments to take corrective action and increase competition in subsequent years—a hopeful sign for the future of digitization across SSA as well as NAfr and NRME regions.

The critical role of demand-side factors including low average levels of incomes and human capital, together with scarcity of required complementary infrastructure in many countries, however, strongly suggest that increasing the degree of competition in digital markets will by itself not be sufficient to generate widespread adoption of mobile internet and attendant digital services. The set of findings across the demand and supply side of internet markets in this paper suggest that policy actions will be needed on multiple fronts, including public and private investments in general education and business-relevant skills and in complementary infrastructure, especially electricity wherever access is lacking, in addition to supply-side pro-competition policies. The demand-side area of attractiveness or willingness to use of internet and related digital services also seems important based on the subjective response of many non-users indicating that either they don't know what internet is, they don't know how to use it, or they don't find it useful. This raises questions regarding why private markets have not led on their own to the development of handsets and apps that are sufficiently attractive, useful, and easy to use that more people would have become users.[47]

A challenge facing low-income, highly indebted countries in MENA and SSA is how to attract capital to invest in critical digital-related activities, including digital infrastructure as well as attractive digital apps and other technologies for productive use. Where perceived risks remain high, mobilizing blended financing instruments through improved business environments and selective de-risking instruments (partial risk guarantees, structured financial instruments, public-private partnerships, etc.) may be a promising approach to promoting greater competition in the provision of digital services for productive use. To date blended finance instruments have been far less successful than initially expected but are often approached on a transactional basis rather than on a systemic basis addressing risk management (Attridge and Engen 2019). Financiers can manage the greater risks in financing technology generation and adoption by changing the tenor and characteristics of their financing products. Digital technologies decrease the costs of extending shorter-term financing by automating credit underwriting, monitoring, and collections, and by enabling low-cost digital disbursement and repayment processes, thereby making shorter term loans to MSMEs more viable. Importantly, they have the potential to help unbanked enterprises build or rebuild their credit history and then gain access to larger and longer-term loans and other forms of financing. Further reflection on the instruments and technologies available to incentivize investment flows through systemic de-risking may be a promising avenue for further analysis.[48]

Another challenge facing low-income countries is the possibility that digital uptake may actually exacerbate existing inequalities and/or create new ones, absent appropriate countervailing policies. Many studies find significant gaps in uptake across gender and age

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[47] Most of the analysis presented in this paper relies on aggregate data for uptake, which does not differentiate between adoption by households and businesses. However, evidence suggests that the key drivers of uptake on the demand side are quite similar: affordability, capabilities and skills, attractiveness and existence of complementary assets such as electricity are important conditional correlates of uptake for both firms and households (Begazo-Gomez, Blimpo and Dutz, 2022). In addition, especially for the case of sub-Saharan Africa, the distinction between firms and households is highly blurred for micro-size informal firms that provide a large share of employment. This is most evident in the agricultural sector where the distinction between the household and the enterprise does not even exit for a significant share of sectoral employment. In both cases, policies need to address multitudes of constraints for adoption of digital technologies to lead to productive use and increase household/enterprise incomes (ibid.)

[48] See Begazo Gomes, Blimpo and Dutz (2022), especially section 2.4, for a discussion of policy options related to financial instruments that can support development of useful digital apps (which would increase attractiveness) as well as adoption of digital technologies by micro, small and medium sized firms.

groups. The importance of skills may place lower-educated people at a serious disadvantage relative to those who possess more jobs-relevant skills. Furthermore, there is evidence that the pandemic has already exacerbated these divides. Recent Business Pulse Surveys carried out by the World Bank find that while investments in digital technologies have increased during the pandemic, there is a significant gap between large and small firms and this gap is larger in Africa relative to other non-high-income countries (Begazo Gomez, Blimpo and Dutz, 2022).

In conclusion, the paper emphasizes the importance of policies to address the challenge of low internet uptake and use in addition to coverage and provides a framework highlighting the importance for uptake and use of both demand-side affordability, capabilities, and attractiveness factors as well as supply-side policy and regulatory factors affecting market competition. By doing so, the paper raises several questions that require further research prior to the design of appropriate policies to support greater uptake and use. More research is needed to better understand the large degree of heterogeneity across countries and sub-regions within countries, across industries, and across digital technologies beyond internet that likely differentially affect the relative importance of the different factors influencing uptake and use. Beyond the findings of this paper based largely on aggregate country-level data, more country-specific firm-level research is needed at the level of specific industries across agriculture, manufacturing, and services, and at the level of specific digital technologies that add value to general business functions such as sourcing, marketing, and payments and to sector-specific business functions such as irrigation, harvesting and packaging for crop-based agriculture. The findings of this paper coupled with the findings of country, industry and technology-specific research should together help with the much-needed design of more context-specific appropriate policies for the greater uptake and use of digital technologies for productive use.

Annex 1

The composition of regions

Country	Country Code	Network Readiness Index Score	Network Readiness Index Rank	GDP per Capita (Current USD, 2019)	Country	Country Code	Network Readiness Index Score	Network Readiness Index Rank	GDP per Capita (Current USD, 2019)
North Africa (Nafr)					***Sub-SaharanAfrica (SSA)***				
Algeria	DZA	38.93	100	3,976	Angola	AGO	25.99	126	2,810
Djibouti	DJI			3,415	Benin	BEN			1,220
Egypt	EGY	47.56	77	3,019	Botswana	BWA	38.03	102	7,971
Libya	LBY			7,686	Burkina Faso	BFA	30.54	117	787
Morocco	MAR	46.06	81	3,230	Burundi	BDI	22.48	128	261
Tunisia	TUN	44.33	87	3,352	Cabo Verde	CPV	42.33	91	3,604
Non-Rich Middle East (NRME)					Cameroon	CMR	32.76	114	1,507
Iran	IRN	46.29	79	3,115	Central African Republic	CAF			468
Iraq	IRQ			5,658	Chad	TCD	21.85	130	710
Jordan	JOR	48.14	72	4,405	Comoros	COM			1,370
Lebanon	LBN	42.16	93	7,584	Congo	COG			2,359
Syrian Arab Republic	SYR				Côte d'Ivoire	CIV	35.69	108	2,276
West Bank and Gaza	PSE			3,657	Dem. Rep. Congo	COD	22.31	129	581
Yemen	YEM				Equatorial Guinea	GNQ			8,420
Rich Middle East and North Africa (RMENA)					Eritrea	ERI			
Bahrain	BHR	56.09	51	23,443	Eswatini	SWZ	28.76	121	3,895
Israel	ISR	71.51	22	43,589	Ethiopia	ETH	24.9	127	856
Kuwait	KWT	54.61	55	32,373	Gabon	GAB			7,767
Malta	MLT	66.3	27	30,186	Ghana	GHA	40.86	96	2,210
Oman	OMN	56.38	48	15,343	Guinea	GIN	28.5	124	1,058
Qatar	QAT	57.83	42	62,088	Guinea-Bissau	GNB			749
Saudi Arabia	SAU	60.23	40	23,140	Kenya	KEN	45.18	84	1,817
United Arab Emirates	ARE	63.92	34	43,103	Lesotho	LSO	28.56	123	1,113
					Liberia	LBR			622
					Madagascar	MDG	28.8	120	526
					Malawi	MWI	29	119	583
					Mali	MLI	30.4	118	879
					Mauritania	MRT			1,679
					Mauritius	MUS	48.34	71	11,098
					Mozambique	MOZ	26.55	125	504
					Namibia	NAM	35.66	109	5,037
					Niger	NER			554
					Nigeria	NGA	37.51	103	2,230
					Rwanda	RWA	38.65	101	820
					São Tomé and Principe	STP			1,988
					Senegal	SEN	39.48	99	1,430
					Seychelles	SYC			16,199
					Sierra Leone	SLE			528
					Somalia	SOM			320
					South Africa	ZAF	48.88	70	6,001
					South Sudan	SSD			
					Sudan	SDN			753
					Tanzania	TZA	35.83	107	1,086
					The Gambia	GMB	33.68	113	778
					Togo	TGO			893
					Uganda	UGA	31.51	116	794
					Zambia	ZMB	33.93	112	1,305
					Zimbabwe	ZWE	28.74	122	1,156

Source: World Development Indicators and https://networkreadinessindex.org/

Annex 2 – Full results of regressions conducted for this paper

Table A2-16: Are Africa and MENA different from the rest of the world?

VARIABLES	(1) 3G network coverage	(2) 4G network coverage	(3) mobile uptake	(4) mobile internet uptake
Sub-Saharan Africa	-0.157***	-0.137***	-0.0694***	-0.0618***
	(0.0318)	(0.0357)	(0.0247)	(0.0201)
North Africa	0.0567	-0.0503	0.0357	-0.0136
	(0.0523)	(0.0887)	(0.0449)	(0.0344)
Non-Rich Middle East	-0.0536	-0.0487	-0.0442*	0.0232
	(0.0820)	(0.128)	(0.0246)	(0.0324)
GDP Per Capita, constant PPP	0.0162***	0.0243***	0.0218***	0.0166***
	(0.00204)	(0.00299)	(0.00230)	(0.00193)
GDP per capita squared	-0.000216***	-0.000329***	-0.000332***	-0.000196***
	(3.98e-05)	(6.80e-05)	(5.17e-05)	(4.25e-05)
GDP per capita cubed	8.21e-07***	1.37e-06***	1.45e-06***	7.08e-07***
	(1.99e-07)	(3.97e-07)	(2.93e-07)	(2.20e-07)
year = 2011	0.0281**	0.201***	0.0231***	0.0221***
	(0.0118)	(0.0412)	(0.00214)	(0.00512)
year = 2012	0.0860***	0.291***	0.0423***	0.0531***
	(0.0143)	(0.0512)	(0.00291)	(0.00621)
year = 2013	0.128***	0.384***	0.0558***	0.0859***
	(0.0159)	(0.0488)	(0.00451)	(0.00716)
year = 2014	0.182***	0.501***	0.0717***	0.120***
	(0.0166)	(0.0477)	(0.00476)	(0.00794)
year = 2015	0.236***	0.602***	0.0901***	0.154***
	(0.0175)	(0.0470)	(0.00519)	(0.00851)
year = 2016	0.267***	0.667***	0.101***	0.182***
	(0.0187)	(0.0466)	(0.00571)	(0.00893)
year = 2017	0.293***	0.740***	0.108***	0.212***
	(0.0189)	(0.0458)	(0.00608)	(0.00882)
year = 2018	0.315***	0.802***	0.114***	0.241***
	(0.0195)	(0.0436)	(0.00633)	(0.00887)
year = 2019	0.331***	0.828***	0.121***	0.266***
	(0.0197)	(0.0437)	(0.00652)	(0.00881)
year = 2020	0.381***	0.880***	0.143***	0.311***
	(0.0212)	(0.0441)	(0.00744)	(0.00937)
Constant	0.396***	-0.316***	0.319***	-0.00547
	(0.0294)	(0.0598)	(0.0283)	(0.0192)
Observations	1,976	1,322	2,108	2,084
R-squared	0.589	0.626	0.701	0.714

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A2-2: Conditional correlates of mobile internet uptake: Skills (2010-2020)

Dependent variable: mobile internet uptake	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Expected years of schooling	0.0197***						0.00669*		
	(0.00400)						(0.00354)		
Harmonized Test Scores		0.000703***						7.59e-05	
		(0.000199)						(0.000221)	
Learning-Adjusted Years of Schooling			0.0285***						0.00639
			(0.00514)						(0.00697)
Literacy rate, youth total					0.00174***				
					(0.000597)				
Literacy rate, adult total				0.00176***					
				(0.000540)					
School enrollment, secondary gross						0.00179***			
						(0.000490)			
GDP Per Capita, constant PPP	1.79e-05***	1.92e-05***	1.52e-05***	1.43e-05***	1.60e-05***	1.42e-05***	8.20e-06	9.09e-06	9.26e-06
	(2.19e-06)	(2.32e-06)	(2.55e-06)	(2.69e-06)	(2.55e-06)	(2.32e-06)	(9.89e-06)	(1.01e-05)	(9.99e-06)
GDP per capita squared	-0.000214***	-0.000253***	-0.000188***	-0.000155***	-0.000185***	-0.000175***	-6.64e-05	-8.02e-05	-8.37e-05
	(4.57e-05)	(4.79e-05)	(5.03e-05)	(5.10e-05)	(5.08e-05)	(4.31e-05)	(0.000136)	(0.000138)	(0.000137)
GDP per capita cubed	7.89e-07***	1.01e-06***	7.16e-07**	5.48e-07**	6.89e-07**	6.53e-07***	1.34e-07	1.95e-07	2.14e-07
	(2.53e-07)	(2.77e-07)	(2.77e-07)	(2.69e-07)	(2.78e-07)	(2.04e-07)	(5.79e-07)	(5.85e-07)	(5.80e-07)
year = 2011				0.0631***	0.0629***	0.0240***			
				(0.0159)	(0.0162)	(0.00635)			
year = 2012				0.0895***	0.0913***	0.0591***			
				(0.0162)	(0.0165)	(0.00768)			
year = 2013				0.135***	0.137***	0.0925***			
				(0.0179)	(0.0180)	(0.0101)			
year = 2014				0.146***	0.149***	0.122***			
				(0.0182)	(0.0184)	(0.0108)			
year = 2015				0.176***	0.187***	0.163***			
				(0.0203)	(0.0196)	(0.0111)			
year = 2016				0.223***	0.227***	0.200***			
				(0.0176)	(0.0177)	(0.0116)			
year = 2017				0.237***	0.235***	0.233***			
				(0.0196)	(0.0201)	(0.0110)			
year = 2018	0.0104**	0.0153***	0.0134***	0.259***	0.259***	0.251***	0.0244***	0.0249***	0.0247***
	(0.00509)	(0.00408)	(0.00436)	(0.0178)	(0.0179)	(0.0113)	(0.00197)	(0.00197)	(0.00199)
year = 2019				0.210***	0.194***	0.236***			
				(0.0147)	(0.0178)	(0.0145)			
year = 2020	0.0734***	0.0797***	0.0765***			0.108***	0.0755***	0.0765***	0.0764***
	(0.00506)	(0.00484)	(0.00489)			(0.00804)	(0.00401)	(0.00415)	(0.00401)
Constant	-0.0175	-0.103	0.0164	-0.154***	-0.179***	-0.125***	0.231*	0.264	0.245*
	(0.0308)	(0.0688)	(0.0232)	(0.0315)	(0.0418)	(0.0227)	(0.124)	(0.163)	(0.137)
Observations	490	483	483	424	418	1,217	490	483	483
R-squared	0.806	0.809	0.820	0.746	0.752	0.751	0.728	0.728	0.729
Number of country							172	171	171

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A2-3: Conditional correlates of mobile internet uptake: Prices (2018-2020)

Dependent variable: mobile internet uptake	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
GNIpc mobilebbdata15GB	-0.00371**									0.000241								
	(0.00176)									(0.000350)								
GNIpc mobiledatavoicelow		-0.00333***									4.76e-05							
		(0.000615)									(0.000198)							
GNIpc mobiledatavoicehigh			-0.00170***									-9.02e-06						
			(0.000437)									(0.000133)						
PPP mobilebbdata15GB				-0.00335***									0.000363					
				(0.000690)									(0.000332)					
Price, low data & voice, PPP					-0.00175***									1.13e-05				
					(0.000528)									(0.000158)				
Price, high data & voice, PPP						-0.00101***									4.19e-05			
						(0.000302)									(8.02e-05)			
USD mobilebbdata15GB							-0.00425***									0.000573		
							(0.000957)									(0.000462)		
USD mobiledatavoicelow								-0.00282***									0.000106	
								(0.000734)									(0.000240)	
USD mobiledatavoicehigh									-0.00188***									6.44e-05
									(0.000506)									(0.000142)
GDP Per Capita, constant PPP	1.98e-05***	1.92e-05***	1.93e-05***	2.34e-05***	2.30e-05***	2.21e-05***	2.42e-05***	2.41e-05***	2.36e-05***	-8.21e-07	-8.21e-07	-9.00e-07	2.22e-07	-2.94e-09	-3.65e-08	-1.06e-06	-1.36e-06	-1.39e-06
	(2.12e-06)	(1.94e-06)	(2.03e-06)	(1.70e-06)	(1.73e-06)	(1.78e-06)	(1.66e-06)	(1.63e-06)	(1.67e-06)	(5.49e-06)	(5.58e-06)	(5.58e-06)	(6.06e-06)	(6.36e-06)	(6.25e-06)	(5.37e-06)	(5.52e-06)	(5.52e-06)
GDP per capita squared	-0.000237***	-0.000226***	-0.000225***	-0.000308***	-0.000305***	-0.000290***	-0.000301***	-0.000309***	-0.000307***	8.42e-05	8.33e-05	8.36e-05	7.18e-05	7.21e-05	7.27e-05	9.22e-05	9.58e-05	9.60e-05
	(4.61e-05)	(4.30e-05)	(4.45e-05)	(4.28e-05)	(4.30e-05)	(4.33e-05)	(4.22e-05)	(4.15e-05)	(4.16e-05)	(7.79e-05)	(7.89e-05)	(7.82e-05)	(8.61e-05)	(8.96e-05)	(8.81e-05)	(7.77e-05)	(7.94e-05)	(7.95e-05)
GDP per capita cubed	8.73e-07***	8.19e-07***	8.13e-07***	1.24e-06***	1.23e-06***	1.16e-06***	1.15e-06***	1.21e-06***	1.22e-06***	-5.55e-07	-5.49e-07	-5.49e-07	-5.09e-07	-5.03e-07	-5.06e-07	-6.01e-07*	-6.14e-07*	-6.15e-07*
	(2.57e-07)	(2.41e-07)	(2.48e-07)	(2.61e-07)	(2.62e-07)	(2.60e-07)	(2.58e-07)	(2.56e-07)	(2.54e-07)	(3.42e-07)	(3.46e-07)	(3.41e-07)	(3.77e-07)	(3.88e-07)	(3.83e-07)	(3.46e-07)	(3.52e-07)	(3.52e-07)
year = 2019	0.0222***	0.0250***	0.0237***	0.0265***	0.0272***	0.0263***	0.0261***	0.0259***	0.0261***	0.0256***	0.0255***	0.0255***	0.0251***	0.0251***	0.0251***	0.0260***	0.0259***	0.0259***
	(0.00150)	(0.00223)	(0.00145)	(0.00428)	(0.00475)	(0.00420)	(0.00400)	(0.00407)	(0.00393)	(0.00137)	(0.00135)	(0.00133)	(0.00142)	(0.00149)	(0.00146)	(0.00139)	(0.00142)	(0.00141)
year = 2020	0.0605***	0.0606***	0.0601***	0.0595***	0.0603***	0.0560***	0.0621***	0.0619***	0.0585***	0.0511***	0.0507***	0.0506***	0.0514***	0.0508***	0.0510***	0.0519***	0.0511***	0.0512***
	(0.00467)	(0.00440)	(0.00460)	(0.00609)	(0.00609)	(0.00638)	(0.00571)	(0.00590)	(0.00624)	(0.00363)	(0.00364)	(0.00384)	(0.00374)	(0.00374)	(0.00388)	(0.00371)	(0.00363)	(0.00377)
Constant	0.210***	0.219***	0.215***	0.232***	0.215***	0.219***	0.196***	0.193***	0.199***	0.418***	0.421***	0.422***	0.407***	0.420***	0.418***	0.409***	0.419***	0.420***
	(0.0242)	(0.0198)	(0.0212)	(0.0192)	(0.0204)	(0.0207)	(0.0161)	(0.0169)	(0.0179)	(0.0667)	(0.0682)	(0.0689)	(0.0755)	(0.0796)	(0.0781)	(0.0646)	(0.0666)	(0.0665)
Observations	535	530	533	503	498	500	542	540	540	535	530	533	503	498	500	542	540	540
R-squared	0.776	0.780	0.775	0.776	0.763	0.757	0.780	0.772	0.769	0.698	0.696	0.696	0.701	0.696	0.696	0.699	0.694	0.694
Number of country										183	183	183	181	181	180	186	186	186

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table A2-4: Conditional correlates of mobile internet uptake: Inequality (2010-2020)

Dependent variable: mobile internet uptake	(1)	(2)	(3)	(4)	(5)	(6)
Income share of top 1 percent	-0.248*		-0.112		0.00243	
	(0.127)		(0.142)		(0.0883)	
Income share of top 10 percent		-0.306***		-0.292***		-0.0541
		(0.0884)		(0.107)		(0.106)
Top 1% * gdp per capita			-0.00831			
			(0.00840)			
Top 10% * gdp per capita				-0.000578		
				(0.00358)		
GDP Per Capita, constant PPP	0.0193***	0.0181***		0.0184***	0.0142***	0.0141***
	(0.00147)	(0.00159)		(0.00240)	(0.00457)	(0.00457)
GDP per capita squared	-0.000228***	-0.000212***		-0.000213***	-0.000104*	-0.000102*
	(3.20e-05)	(3.32e-05)		(3.42e-05)	(5.93e-05)	(5.93e-05)
GDP per capita cubed	8.15e-07***	7.53e-07***		7.56e-07***	2.46e-07	2.39e-07
	(1.67e-07)	(1.69e-07)		(1.75e-07)	(2.14e-07)	(2.14e-07)
year = 2011	0.0349***	0.0350***		0.0350***	0.0350***	0.0350***
	(0.00270)	(0.00265)		(0.00264)	(0.00256)	(0.00255)
year = 2012	0.0710***	0.0709***		0.0709***	0.0723***	0.0722***
	(0.00375)	(0.00375)		(0.00374)	(0.00389)	(0.00393)
year = 2013	0.106***	0.106***		0.106***	0.110***	0.110***
	(0.00532)	(0.00531)		(0.00532)	(0.00557)	(0.00558)
year = 2014	0.142***	0.142***		0.142***	0.145***	0.145***
	(0.00641)	(0.00643)		(0.00643)	(0.00693)	(0.00693)
year = 2015	0.177***	0.177***		0.177***	0.178***	0.178***
	(0.00742)	(0.00743)		(0.00743)	(0.00805)	(0.00804)
year = 2016	0.202***	0.202***		0.202***	0.206***	0.206***
	(0.00837)	(0.00834)		(0.00836)	(0.00919)	(0.00915)
year = 2017	0.227***	0.227***		0.227***	0.231***	0.231***
	(0.00839)	(0.00836)		(0.00839)	(0.00968)	(0.00963)
year = 2018	0.254***	0.253***		0.253***	0.257***	0.257***
	(0.00832)	(0.00824)		(0.00829)	(0.0101)	(0.0101)
year = 2019	0.276***	0.275***		0.275***	0.279***	0.279***
	(0.00831)	(0.00822)		(0.00827)	(0.0105)	(0.0105)
Constant	-0.00541	0.106**	-0.0272	0.0994*	-0.0217	0.00360
	(0.0263)	(0.0483)	(0.0276)	(0.0566)	(0.0568)	(0.0756)
Observations	1,630	1,630	1,630	1,630	1,630	1,630
R-squared	0.806	0.815	0.807	0.815	0.853	0.853
Country FE	No	No	No	No	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of country					165	165

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A2-5: Conditional correlates of mobile internet uptake: Regulatory variables (2010-2018)

Table 11: Conditional correlates of mobile internet uptake: Regulatory variables (2010-2018)

Dependent variable: mobile internet uptake	(1)	(2)	(3)	(4)	(5)	(6)
MTR_usd	-0.819**			-0.757***		
	(0.326)			(0.255)		
HHI Index TeleG data		-0.292***			-0.159***	
		(0.0465)			(0.0439)	
Overall ITU index			0.00202***			0.000247
			(0.000443)			(0.000477)
GDP Per Capita, constant PPP	0.0219***	0.0176***	0.0189***	0.00388	0.0108**	0.00997
	(0.00190)	(0.00157)	(0.00210)	(0.00673)	(0.00477)	(0.00669)
GDP per capita squared	-0.000298***	-0.000215***	-0.000277***	6.70e-05	-8.14e-05	4.18e-05
	(4.90e-05)	(3.73e-05)	(5.59e-05)	(0.000121)	(5.41e-05)	(0.000130)
GDP per capita cubed	1.33e-06***	7.98e-07***	1.37e-06***	-7.06e-07	1.88e-07	-7.73e-07
	(3.11e-07)	(2.02e-07)	(3.73e-07)	(6.40e-07)	(1.92e-07)	(7.79e-07)
year = 2011	0.0289***	0.0248***	0.0215***	0.0331***	0.0302***	0.0302***
	(0.00706)	(0.00457)	(0.00467)	(0.00728)	(0.00360)	(0.00382)
year = 2012	0.0653***	0.0566***	0.0494***	0.0733***	0.0656***	0.0655***
	(0.00923)	(0.00554)	(0.00608)	(0.00926)	(0.00465)	(0.00521)
year = 2013	0.0917***	0.0832***	0.0816***	0.105***	0.100***	0.101***
	(0.0127)	(0.00748)	(0.00708)	(0.0114)	(0.00606)	(0.00689)
year = 2014	0.125***	0.118***	0.110***	0.138***	0.135***	0.134***
	(0.0141)	(0.00821)	(0.00834)	(0.0127)	(0.00726)	(0.00863)
year = 2015	0.156***	0.151***	0.141***	0.171***	0.168***	0.167***
	(0.0155)	(0.00856)	(0.00924)	(0.0137)	(0.00816)	(0.00970)
year = 2016	0.185***	0.179***	0.165***	0.200***	0.199***	0.195***
	(0.0164)	(0.00888)	(0.0101)	(0.0147)	(0.00923)	(0.0108)
year = 2017	0.206***	0.208***	0.191***	0.224***	0.228***	0.222***
	(0.0168)	(0.00875)	(0.00998)	(0.0151)	(0.00977)	(0.0113)
year = 2018	0.230***	0.237***	0.214***	0.248***	0.256***	0.248***
	(0.0174)	(0.00875)	(0.0105)	(0.0157)	(0.0103)	(0.0123)
year = 2019	0.247***	0.261***		0.266***	0.281***	
	(0.0184)	(0.00876)		(0.0165)	(0.0109)	
year = 2020	0.274***	0.299***		0.293***	0.310***	
	(0.0195)	(0.00879)		(0.0163)	(0.00950)	
Constant	-0.00896	0.106***	-0.145***	0.145*	0.0904	-0.0291
	(0.0263)	(0.0262)	(0.0236)	(0.0780)	(0.0658)	(0.0702)
Observations	1,259	2,033	1,615	1,259	2,033	1,615
R-squared	0.835	0.765	0.759	0.861	0.829	0.807
Country FE	No	No	No	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Number of country				128	190	184

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A2-6: Too many exits in SSA?

Dependent Variable: mobile internet uptake	(1)	(2)	(3)	(4)
No. of exits	-0.0640***	0.00514		
	(0.0139)	(0.00801)		
Max. market share of exited firms			-0.520***	-0.134
			(0.148)	(0.0856)
GDP Per Capita, constant PPP		0.0251***		0.0237***
		(0.00218)		(0.00227)
GDP per capita squared		-0.000363***		-0.000335***
		(5.63e-05)		(5.79e-05)
GDP per capita cubed		1.68e-06***		1.52e-06***
		(3.67e-07)		(3.71e-07)
Constant	0.503***	0.210***	0.497***	0.228***
	(0.0159)	(0.0176)	(0.0149)	(0.0181)
Observations	214	178	214	178
R-squared	0.058	0.756	0.076	0.759

Robust standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1