Connecting the Continent: The Drivers of Participation in Africa's Digital Economy

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List of Abbreviations

5G	Fifth generation
AfCFTA	African Continental Free Trade Area
AI	Artificial intelligence
B2B	Business-to-business
CapEx	Capital expenditure
DAI	Digital Access Index
DDI	Digital Divide Index
FDI	Foreign direct investment
FWA	Fixed wireless access
GB	Gigabyte
GDP	Gross domestic product
GNI	Gross national income
GSMA	Global System for Mobile Communications
ICT	Information and communications technology
IoT	Internet of things
ITU	International Telecommunications Union
LDC	Least developed countries
Mbps	Megabits per second
NRI	Network readiness index
OECD	Organisation for Economic Co-operation and Development
PPP	Public-private partnership
RIA	Research ICT Africa
SDG	Sustainable Development Goals
Tbps	Terabits per second
UNESCO	United Nations Educational, Scientific and Cultural Organization
VR	Virtual reality

Abstract

While technology has reshaped the economic landscape over the past decade, disruptive technologies also contribute to economic and social inequalities between 'connected' and 'unconnected' countries and individuals. For technology to fulfil its economic and social potential (creating jobs, access to health, etc.), the foundation for a digital economy must be present: digital infrastructure, basic and higher education, digital literacy and skills, social platforms, financial services, and entrepreneurial innovation. To unlock the benefits of internet usage among households in sub-Saharan Africa, and the subsequent injection of money and talent into the continent's digital economy, it is crucial to identify the key constraints faced by individuals in adopting internet services. The current study draws on the theoretical and empirical literature to construct and test hypotheses for internet adoption in South Africa, Nigeria, and Kenya. Specifically, this study examines three unique sets of determining factors of mobile internet adoption: a) physical infrastructure (electricity supply); socioeconomic factors (income level, urban or rural location, age, and education level, and c) perspective factors (number of close friends on social media platforms, and face-to-face time with interest groups) shaped by network effects.

This study has found that the most significant determinant of internet adoption across all three countries is education level. Increasing rates of tertiary education could help catalyse internet adoption and meaningful participation in the digital economy, over the coming years. In terms of the physical access dimension of internet adoption, even though the expectation was that electricity access would not be positively correlated with internet adoption in South Africa, those with electricity access were found to be 2.4-times more likely to be connected than those without electricity access. In Nigeria, those with access to electricity were almost 2-times more likely to be internet users, while electricity access was not statistically significant for internet adoption in Kenya. In terms of the perspective dimension of internet adoption, having close friends on social media was found to be a strong determinant of being connected to the internet across all three countries.

Chapter 1: Introduction

1.1 Background to the study

Widespread digital connection through the internet has become a defining feature of our time. The latest estimates pin the number of devices connected to the internet at 21.7 billion – almost 2.8 devices per person. On average, an excess of 74,500 gigabytes (GB) of data are transmitted over the internet every second, with 99% of global internet traffic carried by roughly 400 active undersea fibre cables spanning 1.2 million kilometres. Total international bandwidth has increased more than sixfold between 2008 and 2016, from 30 terabits per seconds (Tbps) to 185 Tbps (ITU/UNESCO Broadband Commission for Sustainable Development, 2019b). All this internet traffic represents a burgeoning digital economy: every minute, US$1.6 million is spent on e-commerce platforms, 9,132 connections are made on LinkedIn, 28,000 subscribers are watching Netflix, and 500 hours of content is uploaded to YouTube (Statista, 2021).

Whereas the first users of the internet were connected via dialup technology through phone lines, internet connectivity today is powered by broadband technology, which provides a wider range of frequencies at a higher speed without interfering with a telephone line. Broadband services can be provided as fixed broadband through dedicated physical links of high-speed internet to homes, office buildings, shopping malls and airports, or through mobile broadband via mobile and smart devices. At 47% penetration globally in 2018 (GSMA, 2019), mobile broadband connects most users to the internet today. As mobile devices become more widely available and cheaper, mobile broadband represents an opportunity to connect the roughly 2.9 billion unconnected people (Statista, 2021) and catalyze economic growth through the digital economy, especially in poorer countries, many of which are in Africa.

The mobile networks through which the world connects to the internet have evolved through generations of wireless technology standards. These networks have ranged from the first generation – 1G – rolled out in Japan in 1979 – to 3G (during which the Blackberry and Apple iPhone were launched) to the current global standard of 4G connection (which has enabled high-quality video streaming for millions) to 5G. 4G is expected to dominate the mobile technology spectrum in the near future, exceeding half of all connections worldwide by 2019 and peaking at 62% in 2023 (ITU, 2018). 5G networks, which are starting to be rolled out in some countries, would enable a global internet of things (IoT) – the seamless sharing of data between billions of connected devices. Transformative technologies such as artificial

intelligence (AI) and IoT require information and communication (ICT) infrastructure that can manage rapidly evolving user needs to foster a thriving digital economy.

Broadband connectivity and the underlying ICT infrastructure that enable it is widely recognised as an important catalyst to help achieve the 17 United Nations (UN) Sustainable Development Goals (SDGs) and their 169 targets. Most relevant is Goal 9: Industry, innovation and infrastructure, and specifically, Target 9c: To significantly increase access to information and communication technologies (ICT) and strive to provide universal and affordable access to internet in LDCs by 2020. The importance of ICTs in achieving the SDGs is highlighted in the UN's 2030 Agenda for Sustainable Development: "The spread of information and communication technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies" (UN, 2015, p. 5). Given the unique characteristics of the African continent, the region's knowledge societies (those which identify, produce, process, transform, disseminate, and use, information to build and apply knowledge for human development) will probably look very different to those in other regions of the world. To paint an accurate picture of this demographic, a study into the drivers of participation in the digital economy should analyse the level of education, literacy skills, and other socio-economic factors of participants in the African digital economy.

Although people across the world have increasingly been reaping the social and economic benefits of connecting to the internet, a significant digital divide has emerged between and within countries and regions, with almost three billion people still not connected. According to the Organisation for Economic Co-operation and Development (OECD), the digital divide refers to the "gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to both their opportunities to access ICTs and to their use of the internet for a wide variety of activities" (OECD, 2001, p. 5). In 2021, 4G coverage in Africa stood at 49% of the population (and 33% for 3G), slightly more than half of the global coverage of 88%. Only 33% of individuals in Africa are internet users, compared to rates as high as 87% in Europe and 81% in the Americas (ITU, 2021). However, less developed countries seem to be catching up gradually when it comes to internet access and adoption. It took lower-to-middle income countries nine years to reach a 75% coverage threshold for basic network coverage (2G) after high income countries reached that threshold; the lag between high income and lower-to-middle income countries to reach the 75% threshold for 3G was just six years (Pathways for Prosperity Commission, 2018). Considering that almost two-thirds of the world population (excluding North America) lives within 50 kilometres of an active fiber point

(ITU/UNESCO Broadband Commission for Sustainable Development, 2019b), the lag, or so-called 'last-mile problem', for 4G and 5G could be less. Encouraging as this may be, it merely underscores that a developing region like Africa will have a different journey compared to developed regions in connecting its citizens to the internet and building a thriving digital economy. A study into the drivers of the digital economy in Africa should therefore consider the continent's unique characteristics and how these would impact internet adoption.

Efficiency, effectiveness, and equity are important in leveraging information to promote development (Chen, 2021). The internet provides a platform for the exchange of information that can catalyse the development process. Small business owners can find product information and build business networks, students can find educational content, people of working age can find job opportunities, and governments can utilise the internet to provide public services. However, the potential benefits of ICTs cannot be realised without access and usage. Unequal levels of access and usage create a digital divide between individuals, countries, and regions at different socioeconomic levels. The disparity in ICT access and usage across the world – despite the proven benefits thereof – has driven researchers to investigate the determinants of the digital divide. The determinants of the digital divide cannot be assumed to be universal and timeless. The determinants of technology adoption in rich countries will be different to those in poor countries, while cultural aspects also play an important role. Technology is by nature constantly evolving, meaning that the determinants of adopting cloud computing or virtual reality (VR) technology in the 2020s will not mirror the determinants of dialup internet in the 1990s.

Efforts around the world have been focused on meaningful universal broadband connectivity, whereby global broadband adoption is accessible, affordable, and relevant, as well as safe, impactful, and trusted (ITU/UNESCO Broadband Commission for Sustainable Development, 2019b). Broadband is defined as download and upload speeds of at least 25 and 3 megabits per second (Mbps) respectively (Federal Communications Commission, 2020), while mobile broadband is considered a 3G connection and above. The World Bank's 2016 Development Report, *Digital dividends*, highlights that through inclusion, efficiency, and innovation, universal digital access can provide poor and disadvantaged communities with opportunities that were previously unattainable. The report cites Kenya as an example, where the cost of sending remittances decreased by 90% after the introduction of the digital payment system M-Pesa. Investment in infrastructure is listed as one of the catalysts to deliver universal digital access. Kenya's example illustrates that for digital infrastructure investments in Africa to

create meaningful social impact and capitalise on market opportunities, investors, entrepreneurs, and governments need to consider the unique challenges faced by the continent's citizens.

The Broadband Commission for Sustainable Development was established by two UN agencies, the International Telecommunications Union (ITU) and United Nations Educational, Scientific and Cultural Organization (UNESCO), and engages in high-level advocacy to expand broadband access in developing countries and underserved communities. The Commission engages with various stakeholders to encourage a higher priority focus on the development of broadband infrastructure and services so that all countries can reap the benefits of this technology. The Broadband Commission for Sustainable Development 2025 targets include broadband internet user penetration of 75% worldwide, 65% in developing countries, and 35% in least developed countries (LDCs), by 2025. The affordability of data has been identified as one of the major obstacles in achieving universal internet access. More than 1.3 billion people live in countries where basic mobile data plans (of 1GB of data per month) are not affordable. Average affordability of data is best in South Asia at 1.2% of average monthly income per capita and worst in sub-Saharan Africa at 6.8%, although affordability in sub-Saharan Africa has improved significantly from 13.2% in 2016. Organisations such as the Broadband Commission for Sustainable Development have advocated for a so-called '1 for 2' target whereby 1GB of mobile broadband data should be available for 2% or less of monthly average income. At least 90 countries now have basic mobile broadband prices below 2% of monthly average income, while 69 countries have basic fixed broadband prices below this threshold (ITU/UNESCO Broadband Commission, 2019b).

Broadband connections in Africa crossed the 400 million threshold in 2018, almost twenty times the levels in 2010 (ITU/UNESCO Broadband Commission for Sustainable Development, 2019a). However, compared to other regions, internet use in Africa is the lowest in the world, with most countries below the 20% penetration level required to benefit from network effects. Research ICT Africa's (RIA's) 2018 After Access ICT Access and Use Survey shows that several of the African countries surveyed between 2017 and 2018 are below 15%. Although people in Africa primarily access the internet through mobile phones, mobile broadband connectivity in sub-Saharan Africa remains the lowest in the world at 28% (GSMA, 2021). The reach of fixed broadband in Africa is even more limited. A sharp drop in subscription charges has led to increased penetration in particularly urban areas in sub-Saharan Africa, but Africa still has the lowest fixed broadband penetration in the world.

The World Bank has established two goals as part of the Broadband Commission for Sustainable Development's strategy for connecting Africa through broadband: firstly, to double broadband connectivity levels on the continent between 2016 and 2021, and secondly, to achieve universal affordable and good quality broadband access in Africa by 2030. In its 2019 report, *Connecting Africa Through Broadband*, the Broadband Commission estimates that 220 million new users must still be connected to double broadband connectivity by 2021 and roughly 1.1 billion new people must be connected to achieve universal, affordable, and good quality broadband access in Africa by 2030. Defined as 10Mbps speeds, good quality broadband penetration in sub-Saharan Africa was only 7% in 2018. To reach universal connectivity, the African region alone must connect almost 900 million new users to good quality broadband by 2030, more than 85% of the continental target. At least another 230,000 kilometers of fibre are needed to reach the World Bank's goal of universal internet access in Africa by 2030. With Africa's urban population expected to triple by 2050, an additional 25,000 kilometres will be needed to incrementally densify the largest metros in sub-Saharan Africa (ITU/UNESCO Broadband Commission for Sustainable Development, 2019a).

Increased connectivity on the continent has been driven by large infrastructure investments and increased network coverage. The continent's international undersea fibre capacity has increased almost tenfold since 2010, reaching 100 Tbps in 2018. By September 2018 only three countries in Africa were not connected to undersea cables. African countries have rolled out almost 1.4 million kilometres of terrestrial fibre, of which 936,000 kilometres were active in 2018. Given that 54.2% of people in sub-Saharan Africa live within twenty-five kilometres of an active fibre network node (ITU/UNESCO Broadband Commission for Sustainable Development, 2019a), connecting the unconnected is not impossible. In fact, mobile operators in sub-Saharan Africa increased the coverage of 3G networks from 49% of the population in 2014 to 81% in 2020, connecting 180 million users in the process. Meanwhile, 4G network coverage in the region increased from 5% of the population in 2014 to 51% in 2020 (GSMA, 2021). The newest connectivity innovations for Africa include 5G fixed wireless access (FWA), drones, and balloons. Satellite transmission is also expected to contribute meaningfully to universal access in Africa.

Universal access in Africa is hampered by many other problems and shortcomings. Access to reliable electricity for example, limits the development of digital infrastructure. Electricity is needed to power broadband connectivity, from recharging a mobile device to powering a mobile base station. The household electrification rate in sub-Saharan Africa is the lowest in

the world at 47.9% in 2019, compared to 90% globally (IEA, 2020). Promisingly, US$36.8 billion was invested in electricity infrastructure in sub-Saharan Africa between 2010 and 2019, more than 72% of infrastructure investment with private participation in the region (The World Bank Group, 2020). The crucial relationship between electricity access and mobile internet adoption is an important aspect of the digital divide in Africa.

To show its commitment to universal digital access on the continent, the African Union, in collaboration with various stakeholders such as the ITU and World Bank, has developed a comprehensive Digital Transformation Strategy for Africa for 2020-2030. One of the strategy objectives is that by 2030, all Africans should have affordable (USD 1c per mb), safe, and secure digital access at speeds of at least 6Mbps. The report calls on the leveraging of private investments and public-private partnerships (PPPs) to channel investment and build the digital infrastructure nationally and regionally needed to improve digital services and competitiveness in Africa. According to the report, the private sector has invested US$45 billion in more than 450 African ICT companies over the previous decade. Although 5G technology is being rolled out in African countries like South Africa, the United States, South Korea, and China are leading rollout of this technology. Between 2019 and 2025, mobile operators are expected to invest roughly US$1.3 trillion on capital expenditure (CapEx) worldwide, of which 75% will be spent on 5G technology (GSMA Intelligence, 2020). Digital investment in Africa will be significant over the coming decade, and to ensure that these investments deliver the required returns (financial, economic, and social), it is important to understand the main drivers of participation in the region's digital economy, highlighting the need for a study on the topic.

1.2 Research Problem and Questions

As new internet-based technologies become more established and create novel markets and industries, the countries and regions that lack sophisticated ICT infrastructure and high levels of connectivity will fall further behind and miss out on crucial economic opportunities. To unlock the benefits of internet usage among households in sub-Saharan Africa, and the subsequent injection into the continent's digital economy, it is crucial to identify the key constraints faced by individuals in adopting internet services.

Given the importance of mobile internet to catalyse participation in the African digital economy and the region's low mobile internet adoption rate, it is important to focus on those countries that have passed the 20% mobile internet penetration level needed to leverage the technology's

network effects. The research problem is that it is not yet clear which policy action, and which investment decisions, connect people in Africa most effectively to the internet and the continent's digital economy. Why, even though governments have implemented various policies and along with the private sector have made significant investments into the region's technology infrastructure and digital economy, has adoption on the continent remained low? Research on the determinants of mobile internet adoption in these countries – identifying key determinants along the dimensions of physical infrastructure, socioeconomic factors, and perspective factors – would provide better insight into the most appropriate policy action(s) and allocation of investments to bridge the divide in Africa.

Although it has been established that the digital divide should be analysed by using a multidimensional framework, there is no universally accepted model with which to analyse the digital divide. The literature shows that we need to extend beyond supply-side determinants like more investment to socioeconomic, and in particular perspective, factors to determine the main characteristics of internet users in Africa and what makes them connect to one another. To determine the key determinants of internet adoption in Africa, the present study extends on existing studies by combining a unique set of variables into a widely used framework.

The main research question is:

- What are the most significant determinants of mobile internet adoption in Africa?

Along the key dimensions of internet adoption, the main research question is supported by the following questions:

- What is the impact of infrastructure variables on mobile internet adoption in Africa?
- What is the impact of the socioeconomic variables on mobile internet adoption in Africa?
- What is the impact of the network effect of spending time with interest groups or having more than five close friends on a social network, on mobile internet adoption in Africa?

1.3 Research objectives

The main research objective is:

- To determine the most significant determinants of mobile internet adoption in sub-Saharan Africa.

Incorporating a multidimensional framework, the research objectives are also to determine:

- the most significant infrastructure variable on mobile internet adoption,
- the most significant socioeconomic variables, and
- the most significant perspective variable on mobile internet adoption in the region.

The study will determine whether the conceptual framework of exploring the digital divide among the categories of physical infrastructure, socioeconomic factors, and perspective factors, also applies to mobile internet adoption in Africa. The study aims to determine the most significant determinants of mobile internet adoption in Africa, particularly in countries that have passed the 20% penetration threshold required to exploit network benefits.

1.4 Scope and Justification of the Study

This study will contribute to the digital divide literature by investigating mobile internet, a new technology that has not yet reached saturation in sub-Saharan Africa. The study refines the analytical framework that has been used in digital divide studies like Forenbacher et al (2019), Hasbi & Dubus (2020), and Chen (2021) by working with a novel combination of variables to reflect the most recent developments in mobile internet usage and the socio-economic and demographic characteristics of the African continent. In particular, the current study includes a social engagement variable to investigate the impact of both online and offline social behaviour on mobile internet adoption. While most of the existing digital divide literature is focused on fixed internet access and usage in developed countries, this study adds to the growing, but incomplete literature on the digital divide in Africa, especially concerning mobile internet. The study includes unique perspective factors, which could aid researchers in understanding the social network effects of social media – a critical component of mobile internet usage – and other social and cultural patterns.

While technology has reshaped the economic landscape over the past decade, these disruptive technologies also contribute to existing economic and social inequalities between connected and unconnected countries and individuals. Although many studies have focused on ICT access and usage in explaining the digital divide, the literature on the determinants of mobile internet adoption in Africa is limited. The current study adds to the existing literature in the following ways: a) it is one of the first studies to investigate the determinants of mobile internet adoption in Africa; b) it uses nationally representative household-level data that follow a consistent methodology across the African countries, allowing cross-country comparisons – a rarity in the literature; and c) it aims to establish significant relationships between both supply-side and

demand-side variables and mobile internet adoption, which could help policymakers in the region.

The digital economy is predicted to contribute US$180 billion annually to Africa's economy by 2025, depending on the digital technology usage levels of businesses and the right mix of policy actions (Google & IFC, 2020). Digital investment in Africa will be significant over the coming decade. To ensure that these investments deliver the required returns (financial, economic, and social) it is important to understand the main drivers of participation in the region's digital economy. It is this need-to-know that necessitates a study on the topic. Studying the determinants of mobile internet adoption in Africa should focus not only on physical infrastructure and access to mobile internet, but should equally incorporate a variety of other factors, particularly from the demand-side, to fully understand the mobile internet digital divide in Africa and to recommend policies to narrow it dramatically.

The study focuses on three African countries – South Africa, Nigeria, and Kenya – that have reached high mobile phone adoption and internet penetration levels above the 20% threshold needed to benefit from the technology's network effects. Since these three countries have more evolved digital landscapes compared to the rest of Africa, insights on the determinants of mobile internet adoption in these three countries could help inform a policy framework to catalyse the entire continent's digital economy.

1.5 Organisation of the study

The organisation of this study is as follows: Chapter 1: Introduction, Chapter 2: Literature review, Chapter 3: Methodology, Chapter 4: Discussion of findings, and Chapter 5: Conclusion and recommendations.

Chapter 2: Literature review

2.1 Introduction

This chapter investigates in more depth the literature that underpins the research mandate of this study. The section starts with a brief introduction of the concept of the digital divide, and an overview of how this phenomenon might have unique characteristics in sub-Saharan Africa. The chapter then explores the theoretical framework that informs the digital divide in Africa, after which it discusses the empirical findings on the phenomenon, particularly around mobile internet adoption in the region.

2.2 Theoretical literature

The term 'digital divide' emerged in the mid to late 1990s to describe the gap between those with access to new forms of information technology and those without. In recent years, studies on the digital divide have increasingly focused on the disparity in access to the internet. This could be because the types of information provided by the internet are more varied and unlimited than other ICTs (comprising, for example, elements such as social media, mobile banking, e-Commerce, and the sharing of health data). Furthermore, due to technical and economic factors, access to the internet is still limited in many countries, especially in Africa. New technologies like broadband and social media have emerged as important components of internet access and usage when investigating the digital divide.

2.2.1 Technological Determinism

The dimension of access is informed by technological determinism, a technology-led theory of social change according to which technology is the primary factor of changes in society, while human and social factors are regarded as secondary (Smith & Marx, 1996). Technological determinism implies that everyone (regardless of nationality, social standing, or dependence on digital means to engage in public life) has the same ability to use and benefit from ICTs, assuming everyone has access to these technologies. This supply-side driven theory contends that greater ICT infrastructure (in the case of mobile internet, 3G coverage and above) should lead to greater adoption of ICT technology, including mobile internet technology, thereby narrowing the digital divide. However, as the digital divide widened over time despite expanding service coverage everywhere, it became clear that the digital divide could not be

explained by the dimension of access (supply-side factors) alone, but should rather incorporate other dimensions as well (Mwin & Kritzinger, 2016). Given that only 28% of the population is connected to the internet even though more than 80% is covered by a mobile broadband network, it is clear that in an African context, supply-side interventions alone will not bridge the digital divide.

Given the need to define the digital divide both in terms of access and usage (Hartviksen et al., 2002; Lim, 2002; van Dijk & Hacker, 2003; Selwyn, 2003, 2006), researchers like Van Dijk (2002, 2006) note that the divides of access and usage should be conceptualised along multiple dimensions. For example, disparities in access should be seen along dimensions of hardware, software, and type of internet access, while disparities in usage should be considered along dimensions of education, skills, literacy, and types of usage (Lentz & Oden, 2001; Van Dijk & Hacker 2003). According to Srinuan and Bohlin (2011) and Helbig et al. (2009), the multiple-dimension level of the digital divide is underpinned by categorical factors that support ICT, including socio-economic factors (for example, income or GDP per capita), geographic location (urban or rural), education level, digital skills, and age. Given the multidimensional nature of the digital divide in Africa, a multidimensional approach would have to be taken to analyse the drivers of participation in the African digital economy.

2.2.2 Socio-Economic Factors

From a socio-economic perspective, a widespread theory contends that higher income countries have higher levels of technology adoption and narrower digital divides within them than lower income countries. The inverse is also true: reducing the digital divide can lead to economic growth. A 2018 ITU study (Katz & Callorda, 2018), undertaken to measure the impact of broadband connectivity on economic development, found that a 10% increase in mobile broadband penetration is associated with a 1.8% increase in gross domestic product (GDP) in middle-income countries and a 2% increase in GDP in low-income countries. A 2019 follow-on study by the ITU focusing on Africa (Katz & Callorda, 2019) suggests that a 10% increase in mobile broadband penetration in an African country yields a 2.5% increase in that country's GDP per capita. Clearly, the relationship between income and internet adoption in Africa is a strong one, and should be investigated further, particularly in countries where income levels and internet adoption are comparatively higher.

The geographic dimension of the digital divide – whether a population is urban or rural – has been found to be a key predictor of the digital divide (Billon, Marco, & Lera-Lopez, 2009; Salemink, Strijker, & Bosworth, 2017; Srinuan & Bohlin, 2011). These studies show that urban environments are associated with higher technology adoption and narrower digital divides. Individuals in urban environments access ICTs like mobile broadband easier and cheaper, and these large and dense populations reduce the cost of rolling out and adopting ICT, thus increasing penetration. As such, we would expect internet adoption to be higher in African countries with more urbanised populations. It is predicted that the number of cities on the continent populated by more than a million inhabitants will grow from 68 in 2020 to 85 in 2025, when 45% of the population of the African continent will live in a city (Google & IFC, 2020). Clearly, many countries' rural-urban profiles are changing, which could present novel relationships between location and internet adoption in the region.

Age is also considered to be a factor that strongly affects the digital divide (Salajan, Schonwetter, & Cleghorn, 2010). Many studies show that older people are less likely to adopt new technologies than teenagers (Billon et al., 2009; Srinuan & Bohlin, 2011) and more likely to cite reasons for avoiding new technologies (van Deursen & van Dijk, 2011). However, at least one study (Mwin & Kritzinger, 2016) suggests that once older people accept a specific technology and gain the necessary skills, they may own more technological devices, presumably because of higher income levels. This necessitates further investigation into the relationship between age and internet adoption, especially as it relates to Africa. Consider for example that South Africa, with a population of 60 million people, has a youth population (people younger than 15) of 28.5%, while Spain, with a comparative population size of 47 million, has a youth population of 14.4% (OECD, 2022). Considering predictions that 60% of Africa's population will be under 24 by 2025 (Google & IFC, 2020), the patterns between age and technology adoption that apply elsewhere might not be applicable to Africa's population, where the so-called "cheetah-generation," a cohort of young, business-savvy changemakers who see social problems as business opportunities, will become increasingly influential.

Education can be instrumental in bridging the digital divide, according to studies by Szeles (2018), Mwin and Kritzinger (2016), and Srinuan and Bohlin (2011). More educated individuals tend to be more inclined to use and adopt ICT (Szeles, 2018). Moon, Park, Jung, and Choe (2010) argue that greater literacy translates into a narrower digital divide, making *literacy* the key factor to address for narrowing the digital divide. Education-related determinants of the digital divide include digital skills and knowledge (Mwin & Kritzinger,

2016; Wamuyu, 2015). The lack of these skills and knowledge is considered a key contributor to the digital divide in Africa and elsewhere (Mwin & Kritzinger, 2016). Many African countries have relatively low-quality education systems, high rates of illiteracy, and low rates of digital skills. Furthermore, education levels and technological skills are not uniform across the region, showing disparity even between more developed countries like South Africa, Kenya, and Nigeria. The relationship between education and internet adoption should therefore be investigated in the African context, homing in on the level or levels of education or specific digital skills relevant to internet adoption in Africa.

2.2.3 Social Determinism

The multi-perspective approach of the digital divide supports the theory of social determinism according to which, a particular society is responsible for the development and deployment of technology, and the way any technology is used in a society or culture, reflects that particular society or culture. As such, Srinuan and Bohlin (2011) and Helbig et al. (2009) contend that even though no group of people uses technology differently from other groups, different groups will use technology for specific goals related to their history and social location. Therefore, the digital divide should be considered from *diverse perspectives* by analysing factors like gender, profession, culture, social engagement, language and content, and attitudes toward ICT (Srinuan & Bohlin, 2011). For example, studies suggest that males are generally more inclined to use ICT than females (Akhter, 2003; Orviska & Hudson, 2009; Penard et al, 2012), while ICT adoption is higher among workers in scientific, technical, and research, fields than workers in other professions (Mwin & Kritzinger, 2016). This implies that the combination of variables might not be the same for each of the countries analysed, based on country-specific characteristics.

2.2.4 Diffusion of Innovations Theory

The Diffusion of Innovations Theory outlines how new technological and other innovations spread through societies and cultures. The theory seeks to explain how and why a technology is adopted over a long period, spanning from introduction to widespread adoption. The speed at which a technology spreads is informed by people's perception of that technology (Rogers, 2003). The key participants in adopting a new technology at different stages of its lifecycle, according to the theory, are in chronological order, innovators, early adopters, early majority,

late majority, and laggards. Different countries have different rates of innovation diffusion, which can be affected by a country's rate of urbanisation, education, industrialisation, and development (Halton, 2021). Due to the complexity of the path and its differentiation across different populations, Van Dijk (2006) identified serious problems with the universal application of the Diffusion of Innovation Theory regarding internet and computer technology. As such, the diffusion theory has not been widely applied in the digital divide literature (Sarkar, Pick, and Johnson, 2015).

Applying the Diffusion of Innovations Theory in the context of internet adoption in Africa (where most countries have not reached saturation levels when it comes to participating in the digital economy) could inform digital investment strategies, especially when comparing countries at different levels of uptake. Many developed regions are already at the late majority and laggard stage in terms of internet diffusion, while this is not the case in Africa. The expectation is that the determinants of internet adoption in countries that have passed the 20% penetration threshold needed to benefit from the technological network effects, will be different to those in countries that have not reached this threshold. The determinants will also vary among these countries: For example, South Africa, which has a mobile internet penetration level above 50% – signifying the late-adopters stage – will be different to Kenya and Nigeria who have passed the 20% threshold and are at the early majority stage.

2.2.5 Perspective Factors

Perspective factors include network effects arising from membership in religious, cultural, economic, and other communities, which can also influence the digital divide (Mwin & Kritzinger, 2016; Srinuan & Bohlin, 2011). Studies suggest that being a member of the same group or community can motivate people to adopt certain ICTs because of network effects. This supports the economic theory of network externalities and the bandwagon effect, where one consumer's demand for a product or service is increased because more people have adopted that product or service. For example, if a church distributes its newsletters through WhatsApp, a church member may be motivated to join WhatsApp as to not miss out on any church news.

Various perspective factors have been considered in the literature. Mwin and Kritzinger (2016) and Wetzl (2010) argue that language can be a digital divide determinant, since it conditions an individual's readiness to use ICT, and the language of the content could repel or attract an individual to the technology in question. Kende and Quast (2016) suggest that non-English

content can increase internet adoption and narrow the digital divide in African countries. An individual's attitude toward evolving ICTs has also been found to be particularly important in the context of the digital divide (Srinuan & Bohlin, 2011): a positive attitude, confidence in the advances in ICT, and understanding the advantages of using certain technologies, can fuel rapid adoption of devices and services, helping narrow the divide.

2.3 Empirical literature

The global body of literature on the digital divide and ICT access, usage, and diffusion is extensive. Studies have been undertaken to explore the digital divide at the global, country, state/provincial, and city, level. Many studies have compared the digital divide between and within regions, or between developing and developed countries. Studies have used various lenses to investigate digital divides, such as economic, social, political, demographic, and regulatory, often applying these to specific ICTs such as broadband, mobile cellular, or the internet. Over the last two decades, the digital divide has largely been viewed from an information and device, skill and literacy, and geographical view, while other views of the digital divide include culture and language, content, attitude, occupation, and age and gender (Mwin & Kritzinger, 2016). The existing digital divide literature discusses access and usage on multiple levels by primarily employing a quantitative method (survey or data analysis), while a qualitative research method is sometimes used to complement findings (Srinuan and Bohlin, 2011). As such, it is expected that a digital divide study on the drivers of participation in the African digital economy would employ a multi-level quantitative research method.

Most studies on the digital divide identify socioeconomic and demographic factors like income level, education, digital literacy, age, and gender, as key determinants of internet adoption, supporting the assertion of looking beyond supply-side access determinants. Participation in the digital economy requires internet adoption, and more specifically, mobile broadband adoption. Only a few studies in the literature focus on mobile broadband internet (Chen, 2021; Kongaut and Bohlin 2016), while others consider internet access from home (Coelho, Silva, and Ehrl 2019; Goldfarb and Prince 2008; Grazzi and Vergara 2014). Many studies do not distinguish between fixed broadband access at home or mobile broadband elsewhere (Gillwald, Milek, and Stork 2011; Pénard et al. 2012). Region- and country-level studies focusing on mobile broadband have used different data sources, ranging from national survey data on ICT usage (Kongaut and Bohlin, 2016 for example) to household financial inclusion survey data

from different countries. Evidently, the digital divide can be analysed from various perspectives, including the determinants of internet access and usage.

Digital divide studies on ICT access and usage in Africa have grown over the last decade. Some studies focus on specific sectors, while others have focused on specific countries like Kenya (Wamuyu, 2015), Nigeria (Bankole, Bankole, and Brown, 2011; Odusanya & Adetutu, 2020), South Africa (Ochara & Mawela, 2015; Mbatha, Ocholla, and Le Roux, 2011), Tanzania (Furuholt and Kristiansen, 2007) and Ghana (Alemna & Sam, 2006). Broader studies have investigated the impact of ICT on human development issues, such as health information access (Rhine, 2006). Considering the explosive uptake of mobile phones by the so-called "cheetah generation" for innovation on the continent (Ponelis & Holmner, 2015), recent studies have investigated mobile phone usage for developmental purposes like banking (Mwangi & Brown, 2015) and electronic participation (e-participation) of citizens in services offered over an e-government platform (Ochara & Mawela, 2015). These studies underpin the importance of mobile phones for internet adoption in the region and support the notion that the digital divide in Africa is a multifaceted phenomenon that should be analysed from various perspectives, ranging from issues of physical access to cultural determinants.

Country-level studies provide national policymakers with valuable insights into the determinants of that country's digital divide. However, with Africans increasingly migrating across the continent (The Economist, 2021) and the African Union aiming to build the largest free trade area in the world with the enactment of the African Continental Free Trade Area (AfCFTA) in 2019, there is an increasing need to understand the region-wide population and would-be participants in the digital economy. The borderless nature of the internet and the importance of cross-border remittances for many Africans' livelihoods support a holistic view of the region. Some African countries – notably South Africa, Kenya, and Nigeria – have reached the critical mass needed to benefit from the network effects provided by mobile phone technology. Consequently, these three countries have relatively more advanced digital economies and represent a large fraction of digital investments in the region. South Africa, Kenya and Nigeria represent different parts of the Sub-Saharan African region, and each country has a unique level of technological innovation and adoption, and socioeconomic and demographic features. As such, these three countries would provide representative findings into the drivers of participation in the African digital economy. These findings could help policymakers in countries at equivalent levels of innovation and adoption or with similar socioeconomic and demographic characteristics.

A diverse range of determinants for mobile phone ownership in Africa have been established by country-level studies, utilising a range of models. For example, Grzybowski (2015) used national-level data from South Africa and a logit model to identify network effects, education level, literacy, type of employment and income, as significant determinants. Sekabira and Qaim (2017) used panel data and regression to identify gender and household income as determinants of mobile phone use in rural Uganda. A study in Cameroon based on a logit model identified income as the most significant determinant of mobile phone ownership (Honoré, 2018). Penard et al. (2012) used a logit model to identify gender, year, income, literacy, and education level, as significant factors affecting mobile phone ownership in urban Gabon. Some studies in Africa have used macro-data to analyse the mobile digital divide, such as one analysis of Kenya and Somalia (Brännström, 2012) and another analysis of Ghana and South Africa (Fuchs & Horak, 2008). Still, other studies have used qualitative methods such as interviews, to understand the effects of gender on the mobile digital divide in Rwanda (Mumporeze & Prieler, 2017). Their findings suggest that education level and anxiety towards technology are key determinants. Mobile phone adoption studies on Africa – closely linked to mobile internet adoption – suggest that a logit regression model is the most appropriate method to analyse the region's modern technology adoption patterns.

Although much of the recent digital divide literature on developing countries and Africa focus on mobile phone adoption and use (Forenbacher et al, 2019; Aker and Mbiti, 2010), mobile internet usage has not been studied extensively. Of the few studies focused on mobile internet adoption in sub-Saharan Africa, some adopted a multi-level framework, using various sources of data and different combinations of variables. To answer their question of the drivers of mobile broadband use in developing countries, Hasbi & Dubus (2020) first developed a discrete choice model with time and region effects estimated on four countries (Nigeria, Kenya, Uganda, and Tanzania). They then estimated a second discrete choice model with time and region effects for each country to point out countries' differences. They used a standard logistic regression to estimate their models. Chen (2021) attempted to unravel the factors affecting mobile internet adoption in the Global South (sub-Saharan Africa, Latin America, and Asia) using a logit model to predict the probability of an individual adopting mobile internet. The study categorised its independent variables along the three dimensions discussed above: infrastructure, socioeconomic, and social network effect. In contrast, to identify the main barriers to mobile broadband adoption in West Africa, Rodriguez-Castelan et al (2021) followed the model of Goldfarb and Prince (2008). It focuses on the decision whether to adopt

mobile broadband internet, for which individuals would solve the problem of utility maximisation by comparing mobile internet usage to the consumption of other goods. Given its prominence in the contemporary literature and robustness of results, a multidimensional logit regression model appears to be the most appropriate model to analyse the drivers of participation in the African digital economy.

Apart from attempts to define the digital divide along multiple dimensions, researchers have also tried to define the concept quantitatively. Although various frameworks and indexes have been utilised, there is no widely accepted conceptual model to explain technology utilisation at the country- or provincial/state level (Sarkar, Pick, and Johnson, 2015). On a global level, the Digital Access Index (DAI) was launched by the International Telecommunication Union (ITU) in 2003 to measure individuals' ability in a country to access and use new ICTs. The Index groups variables into five categories: the availability of infrastructure, education level of population, the affordability of digital access, the quality of technology services, and internet usage. However, due to the continually changing nature of technology, indexes like the DAI become outdated. Studies like Alper and Miktus (2019) have added recently available indicators from the Digitisation Index (Katz et al, 2014) to the DAI and incorporated the methodology of the Inclusive Internet Index by Facebook and *The Economist* to rescale indicators along a 0-100 interval, constructing the Enhanced Digital Access Index (EDAI).

At the country-level, the network readiness index (NRI) categorises countries according to technological level by representing factors that increase a country's readiness to introduce new technology. The model categorises variables into indexes of environment (market, infrastructure, regulation), readiness (at individual, firm, and government level) and usage (at individual, firm, and government level). This framework has also been updated multiple times (Sarkar, Pick, and Johnson, 2015) and in its most recent form, the environment index has been expanded to include an additional factor of economic and social impact, and a society's capacity to benefit from ICT. At the regional level, Beynon-Davies and Hill (2007), who define the digital divide as the individual who falls behind the population average regarding internet access and use, created a digital divide index to compare technology adoption rates among 'at risk' groups. At the global level, Corrocher and Ordanini (2002) created an index from six determinants of the digital divide between countries: markets, diffusion, infrastructure, human resources, competitiveness, and competition. Likewise, Hanafizadeh, Saghaei and Hanafizadeh (2009) and Emrouznejad, Cabanda and Gholami (2010) developed the Digital Divide Index

(DDI) by using core ICT indicators that conceptualise and define ICT infrastructure and access and user skill.

Indices are generally unable to establish the cause of digital divide problems other than in the broadest terms. Changes in the rankings of countries have less to do with the ICT sector than GDP per capita, which ICT regulators do not have the agency to change. Esselaar, Gillwald and Stork (2017) show that more than 80% of variation in index scores can be explained by GDP or GNI per capita. Identifying country-specific determinants of technology adoption requires an analysis of individual indicators like gender, urban-rural, and income level. These indicators can only be found in nationally representative demand-side surveys.

The present study aims to use a unique set of variables to reflect recent changes in mobile broadband trends and will follow the approach taken by most contemporary studies on mobile internet adoption in Africa. The study will use a logit regression model using cross-country household survey data. As illustrated by Helbig, Gil-Garcia, and Ferro (2009) and Srinuan and Bohlin (2011) and discussed in Section 2.1, the determinants of the digital divide can be arranged along three dimensions: a) physical infrastructure on the supply-side; b) socioeconomic factors on the demand-side, such as the level of income and education; and c) perspective factors on the demand-side which are shaped by the institutional environment, culture, language, and network effects. As such, the empirical literature will be analysed along these dimensions to generate hypotheses and find the most suitable set of variables for a study on the drivers of participation in the African digital economy.

Compared to other regions, internet use in Africa is the lowest in the world, with most countries below the 20% penetration level required to benefit from network effects. Research ICT Africa's (RIA's) 2018 After Access ICT Access and Use Survey shows that several of the African countries surveyed between 2017 and 2018 are below 15%, with Rwanda and Mozambique at around 10%. Of all 10 African countries surveyed, only in South Africa is more than half the population online. The internet penetration rate in Ghana, Kenya, Lesotho, Nigeria, and Senegal is above the 20% threshold. However, Gillwald & Mothobi (2019) point out that further investigation into the determinants of mobile internet adoption is needed, given that factors like the affordability of data means that internet usage is different to fixed-line internet environments studied in the existing literature.

At the end of 2019, sub-Saharan Africa accounted for 477 million unique mobile phone subscribers, 45% of the population (GSMA, 2020). Smartphone adoption is growing in the

region, accounting for 50% of mobile connections in 2020 as more affordable devices become available. Fixed broadband internet connection remains limited in low-income countries – many in Africa – where fixed broadband subscriptions averaged only 0.74 per 100 people in 2018 (World Development Indicators). Driven by high mobile phone ownership and expanding mobile broadband networks, mobile technologies have the potential to accelerate internet access and usage in less developed parts of the world like sub-Saharan Africa. Mobile broadband coverage has been shown to have large and positive impacts on household consumption levels (World Bank, GSMA, 2020), while mobile internet access and usage have been found to have a positive impact on people's well-being and happiness (GSMA and Gallup, 2018) and the empowerment of women (Bailur and Masiero, 2017). It is argued that access to, and usage of, ICTs reduce poverty by facilitating access to, and the exchange of, information, as well as improving the transparency and accessibility of public services – benefits that would also apply to mobile internet (Chen, 2021).

Furthermore, increased internet adoption will fuel an already growing digital economy (also referred to as the internet economy or *e-Conomy*) in Africa. Growth in the African digital economy is fueled by a fast-growing population of increasingly educated and urban consumers. Increased access to more affordable and faster internet across the region, African startups creating new market opportunities and transforming the African economic landscape, and Africa's commitment to develop the largest single market in the world under the African Continental Free Trade Agreement (AfCFTA) contribute to the investment potential in this vital African economy (Google & IFC, 2020).

Investors are already seeing the market potential of the African digital economy: Venture capital funding in Africa reached an all-time high in 2019 (Google & IFC, 2020). Digital startups demonstrated their ability to provide innovative solutions during the COVID-19 pandemic. For example, partnerships between private healthcare startups and the public sector have expanded testing and the availability of medical records. Based on investment and growth, the main sectors in the African digital economy are fintech, e-Commerce, media, entertainment, healthtech, transport, food delivery, and business-to-business (B2B) e-logistics. Mobile technologies and services contributed 8.6% (or $144.1 billion) to sub-Saharan Africa's total GDP in 2018, while 3.5 million people were employed in the mobile sector (Google & IFC, 2020). The digital economy is predicted to contribute US$180 billion annually to Africa's economy by 2025, depending on the digital technology usage levels of businesses and the right

mix of policy actions (Google & IFC, 2020). This illustrates the importance of a study that analyses the drivers of participation in the African digital economy.

Physical infrastructure

The Broadband Commission on Sustainable Development estimates that US$100 billion (or US$9 billion a year) of investment is needed over the following decade to achieve the UN 2030 goal of universal access to broadband connectivity in Africa (ITU/UNESCO Broadband Commission for Sustainable Development. (2019a). This roughly translates into an investment of US$90 per person. Despite significant investment in ICT infrastructure, internet usage in Africa remains low compared to other regions. For example, despite investing in network infrastructure that covers more than 90% of the population in Rwanda, only 3% of households have a working internet connection (Gillwald & Mothobi, 2019). In Nigeria, Africa's biggest economy and most populous country, household internet penetration remains lower than other countries like South Africa and Kenya. Following the technological determinism of the early 2000s (Lentz and Oden 2001; Lim 2002; etc.), much attention was focused on the importance of investment in physical infrastructure and consequent physical infrastructure access. A study of ICT diffusion in Asia showed that infrastructure investment correlated significantly with ICT growth (Quibria et al., 2003). ICT infrastructure, in turn, has been shown to advance economic and technological development (Robison et al, 2002) and has proved an important factor in developed and developing countries. While some studies on the digital divide in Africa have included an investment variable (Kayisire and Wei, 2016), others have chosen to only focus on demand-side variables (Hasbi and Dubus, 2020). Given the household-level focus of the current study, no investment variable will be used. Rather, the focus of the physical infrastructure dimension will be limited to variables that limit a user's access to mobile broadband on a household level.

One explanation for the digital divide between Africa and the rest of the world can be found in the region's low ICT infrastructure development scores. For example, the ITU's 2017 ICT Development Index, which measures country ICT access, usage, and skills, ranks Africa's most developed economies (South Africa and Nigeria, 92nd and 143rd out of 176 countries, respectively) far behind the rest, while nine out of the bottom ten countries are based in sub-Saharan Africa. The continent's digital infrastructure challenges are compounded by other infrastructure problems and shortcomings. Limited access to reliable electricity, for example, limits the development of digital infrastructure. Electricity is needed to power mobile internet

connectivity, from recharging a mobile device to powering a mobile base station. The household electrification rate in sub-Saharan Africa is the lowest in the world at 47.9% in 2019, compared to 90% globally (IEA, 2020). Compared to other developing regions, electricity access as an obstacle to mobile internet usage is particularly severe in Africa. Citing Rwanda and Senegal as examples, 51% and 40% of the respective population identified electricity access as the reason for not owning a mobile phone (Chen, 2021).

Digital divide studies in Africa have found that the availability of electricity and other infrastructure have been crucial for ICT development and adoption on a region- and country-level (e.g., Sarkar, Pick, and Johnson, 2015). For example, Forenbacher (2019) found that the *type* of electricity supply was a significant determinant of mobile phone ownership in Nigeria. However, as pointed out by e.g. Gillwald & Mothobi (2019), a user accessing broadband internet through their mobile phone does not have to be restricted by household electricity connection. While a fixed internet user needs electricity to connect and charge a laptop, mobile users can still connect to the internet and charge their mobile device elsewhere. As such, a would-be mobile internet user might be affected more by network coverage than electricity supply. Aker and Mbiti (2010) point out that network coverage is usually the first modern technology of any kind in many parts of the developing world, while Odusanya & Adetutu (2020) argue that the failure to control for a network infrastructure effect in a study on broadband adoption across developing countries, could result in omitted variable bias. Although mobile network coverage is an important ingredient to connect to the internet, the impact of electricity access as the primary obstacle of mobile broadband access cannot be underestimated. With no household electricity access, it remains unlikely that a mobile internet user will be able to find electricity access elsewhere. As such, electricity access will be used as the physical infrastructure variable, given its importance for mobile phone adoption in Nigeria and mobile internet adoption in the Global South.

Electricity access levels are disparate across the region. In South Africa, almost 90% of the population is connected to the main electricity grid. In Kenya and Nigeria, between 60% and 70% of the population is connected to the main grid, with between 20% and 25% entirely off grid. Interestingly, in these countries a significant portion of the population uses other electricity sources: in Kenya almost 15% of households use solar or other energy sources, while more than 10% of the population in Nigeria use generators (Research ICT Africa, 2018). Despite lower electricity access than Nigeria, Kenya's internet adoption rate is higher, prompting questions about the relationship between electricity access and internet adoption in

the region. Given its importance for accessing mobile broadband, the expectation is that electricity access would increase the probability of being connected to the internet. However, in a country like South Africa with universal electricity access, electricity access is not expected to have a significant impact on internet adoption. Therefore, the expectations for this study are:

- The variable of electricity access will not increase the probability of adopting the internet (the dependent variable) for South Africa.
- The variable of electricity access will increase the probability of internet adoption for Nigeria and Kenya.

Socioeconomic factors

Digital divide barriers are no longer just technological but also include educational, cultural, and linguistic dimensions. Neglecting to sufficiently invest in human capital could result in the 'last mile' challenge becoming the 'lost mile' (Ponelis & Holmner, 2015), where technology actually increases the digital divide. A study by the World Bank (Chen, 2021) on mobile internet adoption in the Global South supports the view that in addition to infrastructure investment – the main focus of many developing countries so far – demand-side factors are critically important. According to Chen (2021), mobile internet adoption in the developing world is less likely among those with lower levels of income, women, the elderly, rural dwellers, and the less educated. These factors should therefore be analysed on a cross-country level to understand the mobile broadband digital divide in the sub-Saharan African region.

Digital exclusion in Africa has been shown to be primarily an issue of poverty (Gillwald & Mothobi, 2019). Rodriguez-Castelan et al (2021), who analysed the determinants of mobile internet adoption in West Africa, conclude that low levels of household consumption and the relatively high price of mobile services are key obstacles to internet adoption by individuals in West Africa. A digital divide study focused on Africa (Sarkar, Pick, and Johnson, 2015) used as its income variable not only GNI per capita but also included industry output, manufacturing output, agricultural exports, and foreign direct investment (FDI). Other digital divide studies have used a more citizen-focused approach of using GDP per capita (Kayisire and Wei, 2016) or GNI per capita as its economic variable. While income has been shown to increase technology use (Baliamoune-Lutz, 2003; Dasgupta, 2005), industry and manufacturing have not been found to be important (Pick, Nishida, and Sarkar, 2014). Since this study takes a user-centric approach rather than an industry-wide one, household-level data will be used, from which the income variable will be created. The expectation is that internet adoption in South

Africa, Nigeria and Kenya would be associated with higher levels of income. Therefore, the expectation for this study is:

- The variable of total income will increase the probability of internet adoption for Nigeria, Kenya and South Africa

Related to income, affordability remains a crucial factor for determining internet usage and the digital divide in Africa. Since mobile phone penetration is already high in most African countries (Gillwald & Mothobi, 2019), the cost of mobile data could be a key enabler or deterrent for Africans connecting to the internet on their phones. The affordability of broadband connection keeps many from connecting, with monthly subscription rates in sub-Saharan Africa twice as expensive as in North Africa (ITU/UNESCO Broadband Commission for Sustainable Development, 2019a). Even in countries where there is extensive coverage, such as South Africa, Rwanda, and Lesotho, device and data cost remains a major obstacle to mobile internet uptake. Katz & Callorda (2019) found that pricing is a key enabler for the adoption of mobile broadband technology: a 10% decrease in mobile broadband prices yields an increase in the uptake of the technology by more than 3.1%. On a country level, Mwesige (2004) established that poverty and the high cost of phones and computers hamper internet penetration in Uganda, while Tlabela et al (2007) suggest that ICT access in South Africa could only be improved if telecommunication costs were reduced and infrastructure issues resolved. However, to the demand-side focus of recent literature (Kayisire and Wei, 2016), not all region-wide studies of Africa include a technology cost factor. Due to the user-centric focus of the current study, no technology cost variable (a supply-side variable) will be used.

In terms of demographics, the African population is getting younger and more urbanised. Nineteen out of the twenty fastest-growing countries in the world are in Africa and 60% of the population will be under 24 by 2025 (Google & IFC, 2020). It is predicted that the number of cities on the continent populated by more than a million inhabitants will grow from 68 in 2020 to 85 in 2025, by when 45% of the African population will live in a city (Google & IFC, 2020). Sixty percent of the urban population go online via their mobile phones and increasing that number to 75% could create 44 million jobs (Google & IFC, 2020). Internet usage tends to be higher among the youth, but only 40% of the continent's youth are internet users – significantly lower than comparable regions like the Arab States (67%) and Asia & Pacific (70%) (ITU/UNESCO Broadband Commission for Sustainable Development, 2019b). How will this changing demographic impact internet adoption in Africa?

Age demographic influenced Japan's internal digital divide (Nishida, Pick, and Sarkar, 2014); in particular, both older and more rural populations were associated with lower technology use. Forenbacher et al (2019) found that age had a negative effect on mobile phone ownership in Nigeria, with older individuals less likely to own a mobile phone. However, the study found that other variables like income, employment status, and education level, could paint a more complete picture. For example, retired individuals were most likely to own a mobile phone, followed by employed, and self-employed, individuals. Bankole et al (2017) found age and gender to have the greatest effect on broadband adoption in Nigeria, implying that broadband adoption would be high among the country's sizable youth population. Given recent demographic developments, the current study will use age as one of its demographic variables. Africa's young population means that the expectation is that internet adoption in South Africa, Nigeria, and Kenya will be associated with younger individuals. As such, the expectation for this study is:

- The variable of age will decrease the probability of internet adoption (the dependent variable) for Nigeria, Kenya and South Africa

The importance of rural areas in Africa cannot be underestimated: it is in the informal sector where the so-called 'cheetah generation' – African graduates and professionals who leverage social needs to create business opportunities (Ayittey, 2015) – can be found spearheading some of the most exciting technological innovations on the continent. The urban-rural divide has been found to be significant across all developing regions, particularly in Africa, where the urban mobile internet adoption rate is more than twice that of rural dwellers (Chen, 2021). Gillwald & Mothobi (2019) finds that both urban-rural and gender gaps in mobile broadband adoption in Africa have grown, with a persistent and significant urban-rural gap. The gap grew from 34% in 2007 to 61% in 2017. Even in South Africa, where mobile broadband covers more than 95% of the population, less than half of rural dwellers are connected to the internet. South Africa's gender gap is relatively low at 12%, while the urban-rural gap is 36%. Moreover, African countries like Rwanda and Lesotho have high urban-rural divides, despite strong supply-side interventions to provide extensive mobile broadband coverage across these countries. Surprisingly, however, rural, or urban, location did not significantly contribute to the probability of mobile phone ownership in Nigeria (Forenbacher et al, 2019), a country with one of the largest rural populations in Africa.

At around 60%, the rate of urbanisation is roughly the same in South Africa and Kenya. Nigeria, the country with the largest population in Africa, has completely different demographics: 57% of the population are rural dwellers, with 43% located in urban areas (Research ICT Africa, 2018). We would expect mobile internet adoption to be positively related to urbanisation in South Africa and Kenya (given the high rates of urbanisation), while we expect the relationship to be negative in Nigeria (given the large rural population). Hence, the expectations for this study are:

- The variable of being an urban dweller will increase the probability of internet adoption for Kenya and South Africa
- The variable of being an urban dweller will decrease the probability of internet adoption for Nigeria

African digital divide studies often include a gender variable, given that a man's decision to buy a mobile phone is often more dominant than a woman's, in patriarchal societies (Bulte et al, 2016). While women were associated with a lower likelihood of owning a mobile phone in studies in Nigeria, Gabon, Senegal, and Tanzania (Forenbacher et al, 2019; Penard et al., 2012; Gillwald, Milek, & Stork, 2010; Chabossou et al, 2009), a lack of gender effect was observed in similar studies in South Africa and Mozambique (Chabossou et al., 2009; Gillwald et al., 2010; Penard et al., 2012). Gillwald & Mothobi (2019) found that at low levels of mobile phone penetration, men are more likely to own a mobile phone, a result that can be explained by inequalities in income and education. The study found that African countries that have passed early-stage adoption, such as South Africa, Kenya, and Nigeria, have much lower gender gaps than countries with low levels of mobile phone penetration. Given that gender gaps in mobile broadband adoption (particularly in countries that have passed the 20% penetration threshold) can be explained by other variables such as levels of income and education, no gender variable will be included in the current study's model.

According to UNESCO, internet-enabled knowledge societies require "the capabilities to identify, produce, process, transform, disseminate and use information to build and apply knowledge for human development" (UNESCO, 2005, p. 27). The skills needed to take part in the knowledge economy are built at the tertiary level (Ponelis & Holmner, 2015). Tertiary education has grown faster in sub-Saharan Africa than any other region in the world: the number of university-enrolled students in the region increased from less than 200,000 in 1970 to 5.9 million in 2010 and 8.3 million in 2019. Despite this rapid growth, sub-Saharan Africa's

tertiary enrolment of 8.4% in 2018 is still the lowest in the world, compared to the global rate of 38% (Bayusuf et al, 2021). Consequently, education might influence mobile internet adoption in Africa differently than in the rest of the world and might also differ between African countries with different education profiles. While the combination of education and ICT can catalyse growth in the region, insufficient ICT skills reduces the quality of online service delivery, hampers potential returns on ICT investments, and disincentivises new investors.

The global digital divide literature has identified education as highly correlated with ICT adoption (Robison and Crenshaw, 2002; Nishida, Pick, and Sarkar, 2014). These studies explain that more educated employees and citizens can use ICTs, while national education drives technology sectors and innovation. Compared to other developing regions, Chen (2021) found that the impact of education on mobile internet adoption is more salient in Africa, highlighting the region's low digital literacy. Gillwald & Mothobi (2019) found that in several African countries including Nigeria and Tanzania, the lack of awareness or skills on how to use the internet keeps many offline. As an encompassing social index, the UN human development index (HDI) has been used by studies like Sarkar, Pick, and Johnson (2015), who chose to include two more separate dimensions – education and training – while other studies have made education the sole focus of the social dimension (Kayisire and Wei, 2016). Since the current study is focused more on citizens (as consumers who participate in the digital economy) than on employees, and due to the importance of education on an information-based technology such as mobile internet, household-level individual education level will be used as the education variable. This is in line with contemporary studies like Chen (2021).

More than 30% of households surveyed in Kenya indicated tertiary education as the highest level of education, followed by 27% in Nigeria and 25% in South Africa. Among the three countries, Nigeria has the highest proportion of people with no education (27%), while virtually everyone in South Africa and Kenya has some level of education. Secondary education is the highest level of education for 60% of households in South Africa and around 40% in Kenya and Nigeria (Research ICT Africa, 2018). Given the purported importance of tertiary education in mobile broadband adoption, it is expected that mobile internet adoption will be positively correlated with education levels in Kenya and Nigeria, while it will be negative in South Africa (due to the country's high internet adoption and low tertiary education level). As such, the expectations for this study are:

- The variable of tertiary education will increase the probability of internet adoption (the dependent variable) for Nigeria and Kenya
- The variable of tertiary education will decrease the probability of internet adoption (the dependent variable) for South Africa

Perspective factors

Predictably, there are countless reasons why people use the internet in Africa. In an environment where voice and SMS tariffs are comparatively more expensive than data offerings, the internet represents a cheaper and easier alternative. The internet is used for business, work, communication, and financial transactions, while various platforms are utilised, ranging from social media to email and search engines. According to South African fintech company Ozow, 93% of online shoppers use their phones, compared to 7% who use computers (Die Burger, 2021). Using focus-group data from Kenya, Nigeria, South Africa, and Rwanda, the Google search engine was identified as the main point of access to other sites (Chair, 2017). Men were found to favour sports and betting content, while women tend to search for fashion, online shopping, and health. The multidimensional nature of the African digital divide highlights the need to consider country-specific variables shaped by perspective factors.

Social media has become an important element of mobile internet adoption in Africa. In a 2018 Pew survey on internet usage in sub-Saharan Africa (Silver & Johnson, 2018), 85% of internet users said they used the internet to stay in touch over the previous 12 months, making it the most popular online activity by far. During the COVID-19 pandemic and subsequent lockdowns, this number has probably increased. The survey found that about half of internet users go online to access news and information about politics and to find information about government services. Forty one percent used the internet to find information about health and medicine, a number which probably also increased significantly during COVID-19.

In a study on the determinants of mobile internet usage in developing countries, Chen (2021) found that social network effects have a significant positive impact on mobile internet usage. People with five or more close friends that use social networks like Facebook or Twitter are 63% more likely to adopt mobile internet than those without close friends on social networks. Hasbi and Dubus (2020) also provided evidence that being part of an online social community has a positive impact on mobile broadband use in sub-Saharan Africa. As such, the current study will include a perspective variable of the number of close friends on a social media

platform (Facebook, Twitter) to see how these relationships vary across South Africa, Nigeria, and Kenya. The expectation is that mobile internet adoption would be positively correlated to many close friends on social media. As such, the expectation for this study is:

- The variable of close friends on social media will increase the probability of internet adoption for Nigeria, Kenya and South Africa

Forenbacher et al (2019), who analysed the determinants of mobile phone ownership in Nigeria, found that the level of disposable income only weakly influenced the likelihood of owning a mobile phone. The authors argue that one explanation could be network effects. The variable of social engagement (belonging to a sports or reading club for example) was statistically significant and positively related to mobile ownership, suggesting that individuals who are engaged in social networks likely know others who own mobile phones and would be more inclined to buy mobile phones themselves, regardless of disposable income. This supports the claim of Ojameruaye (2013) that rural individuals will not purchase a mobile phone unless they perceive a direct benefit that compensates them for the mobile costs. A similar social engagement effect has been observed in South Africa and Gabon (Penard et al., 2012; Grzybowski, 2015), as well as Nigeria, where being a Christian increased the probability of internet services like mobile banking (Bankole et al, 2017).

There is a need for research into whether the same social network effect is present for mobile internet adoption across Africa. As such, the current study will include time spent face-to-face with interest groups (religious, political, or sport) as another perspective variable to reflect the expectation that both offline and online behaviour can contribute to mobile internet adoption. The expectation is that mobile internet adoption in African countries will be associated with more time spent with interest groups. As such, the expectation for this study is:

- The variable of time spent face-to-face with interest groups (cultural, religious, sports) will increase the probability of internet adoption for Nigeria, Kenya and South Africa

2.4 Conclusion

Given the multifaceted nature of the digital divide – particularly as it relates to internet access and usage – the digital divide literature suggests that multiple dimensions of determinant factors should be considered. Combined policy appears to be the current trend in the realm of digital divide policy, favoured by many international organizations undertaking country- and

region-level technology initiatives (Srinuan and Bohlin, 2011). A study that analyses the digital divide and technology adoption in Africa should focus on the region's internet adoption and consider region-specific socioeconomic and demographic characteristics. This might necessitate a framework that is different to those used to analyse internet adoption in other regions. The theoretical and empirical literature is analysed along the most widely used dimensions of the digital divide in order to assemble a quantitative research model that produces meaningful findings on the drivers of participation in the African digital economy.

Household-level digital divide studies are common in the contemporary literature. Hasbi and Dubus (2020) used household data from Nigeria, Kenya, Tanzania, and Uganda over 5 years from 2013 to 2017 to estimate what the determinants of mobile broadband use are in developing economies. Chen (2021) used ten African countries (Ghana, Kenya, Lesotho, Mozambique, Nigeria, Rwanda, Senegal, South Africa, Tanzania, and Uganda) to do a cross-country and -regional (with Asia and Latin America) analysis of mobile internet usage in developing countries. While Hasbi and Dubus used microlevel data sets such as the Living Standards Measurement Study and the Global Findex database, Chen used rich, in-depth information on ICT access and usage from the After Access 2017 survey to investigate the demand-side. The current study will draw on the After Access survey data and use the three countries that best form a representative sample of the region (South Africa, Nigeria, and Kenya) to do a cross-country analysis of countries in Africa.

Many studies on the digital divide and ICT adoption in Africa used the approach of defining the digital divide along multiple dimensions. Accordingly, this study will use a conceptual model that draws on digital divide studies like Sarkar, Pick, and Johnson (2015) and Kayisire and Wei (2016) to construct a set of dimensions by which to evaluate mobile internet adoption in sub-Saharan Africa. This study seeks a) to examine how physical infrastructure, socioeconomic variables, and perspective factors affect mobile internet adoption in Africa, and b) to compare differences in mobile internet adoption across different countries and demographic profiles in the region from the demand side. The study adds to the existing literature in the following ways: a) It is one of the first studies to investigate the determinants of mobile internet adoption in Africa; b) it uses nationally representative household-level data that follow a consistent methodology across the African countries, allowing cross-country comparisons – a rarity in the literature; and c) it aims to establish significant relationships between both supply-side and demand-side variables and mobile internet adoption. This will help policymakers in the region.

Chapter 3: Methodology

3.1 Introduction

This section describes the methodology for carrying out this study, which explores the most significant determinants of mobile internet adoption in Kenya, Nigeria, and South Africa. It begins by explaining the research approach and design adopted to best address this study's research mandate most appropriately. It is followed by the detailed research design, which includes a brief discussion on the data used for this study, including the data source, the sample used, and period. Also included in the chapter is a description and measurement of both the dependent and independent variables used to construct this study's model. Lastly, this section convers any research limitations.

3.2 Research approach and design

The theoretical and empirical literature supports a holistic approach that considers the digital divide on three levels: (1) access, (2) multi-dimensionality, and (3) multi-perspectives (Mwin & Kritzinger, 2016; Srinuan & Bohlin, 2011; Helbig, Gil-Garcia, and Ferro, 2009). A study on the drivers of participation in the digital economy in Africa should focus not only on physical infrastructure and access to mobile internet, but should incorporate various other factors, particularly from the demand-side to fully understand the mobile internet digital divide in Africa and recommend policies to narrow it.

A quantitative research approach entails the use of consistently logical scientific data collection and analysis methods that ensure elimination of bias and achievement of maximum possible objectivity through basing analysis data and results based on observed facts. The main objective of the study is to determine the key determinants of mobile internet adoption in Africa. The second, third, and fourth, objectives, are to determine whether physical infrastructure determinants, socioeconomic factors, and perspective factors are significant in predicting mobile internet adoption. A quantitative research approach is employed to answer these objectives. A quantitative research approach allows for the measurement and analysis of available data to determine the relationship between variables, perform hypothesis testing of research questions, and make predictions about future trends.

3.3 Research design

3.3.1 Sample, Data source and period

Identifying country-specific determinants of technology adoption requires an analysis of individual indicators like gender, urban-rural, and income level, which can only be found in nationally representative demand-side surveys. In 2017-2018, Research ICT Africa conducted access and usage surveys in 10 African countries. Data from these surveys will be used to identify the determinants of mobile internet usage on the continent. Drawing on the Research ICT Africa household survey data, this study will use data on South Africa, Nigeria, and Kenya to compare the mobile broadband adoption variables outlined above. These countries are good candidates for this analysis as they have passed the 20% mobile internet adoption rate needed to benefit from network effects. As such, a study of these countries could inform future policy decisions of African countries that still have nascent digital economies. South Africa, Nigeria, and Kenya also have relative economic and political stability, comparatively developed ICT sectors, and attract foreign direct investment, especially in the ICT sector. These countries collectively make up a large part of the African population and economy; they boast growing digital economies distinctively faster than other countries on the continent.

First, the available data from household-level surveys is analysed to determine the most significant determinants of mobile internet adoption among individuals in the countries selected. Second, the survey data is analysed to determine the impact of specific variables on mobile internet adoption. Three countries – South Africa, Kenya, and Nigeria – were selected as representative of Africa's population. The units of analysis are the individuals who took part in Research ICT Africa's continent-wide After Access survey in 2017-2018 in those countries.

A regression model is built with the purpose of identifying the main determinants of mobile internet adoption in the three countries selected. It assesses whether the results confirm or contradict the hypotheses constructed. In line with many contemporary studies, this study takes a cross-sectional approach to find the main determinants of mobile internet adoption in a specific country at a given time. Since the Research ICT Africa surveys do not target the same households or individuals over time, the researcher is limited in terms of longitudinal analysis. The analytical framework – informed by the existing literature – views internet adoption along the dimensions of physical infrastructure, socio-economic factors, and perspective factors. Hence, a regression model – with mobile internet adoption (Yes/No) as dependent variable and

a combination of physical infrastructure, socio-economic, and perspective variables, as independent variables – is run for each of the three countries.

The data were obtained with permission from the Research ICT Africa database on DataFirst. Descriptive statistics and regression analysis is performed on STATA statistical software that allows for numerous estimation techniques.

3.3.2 Model and variable specification

The main objective of the study is to determine the key determinants of mobile internet adoption in Africa. Based on the analysis of the theoretical and empirical literature above, a logistic regression model is the most applicable model to answer this research question. Following the same analytical framework of Forenbacher et al. (2019), Hasbi and Dubus (2020) and Chen (2021) and using a unique set of variables as informed by the literature review, this analysis tries to estimate the probability of using mobile internet through the following logit model:

$$Mobile\ internet_i = \alpha + \beta_1 electricity\_access_i + \beta_2 income_i + \beta_3 urban_i + \beta_4 age_i + \beta_5 educ_i + \beta_6 interest\_groups_i + \beta_7 social\_media\_friends_i$$

where Mobile internet is a binary variable that equals 1 if individual *i* uses mobile internet, and 0 if not. Given that the dependent variable is a binary variable, a logit model is adopted for the estimation to predict the probability of an individual adopting mobile internet. By logarithmically transforming the outcome variable, it allows the examination of a nonlinear association in a linear way. The logit regression model provides the implied marginal effect of each variable on the probability of someone adopting mobile internet.

Recent studies on the digital divide and ICT adoption in Africa used the approach of defining the digital divide along multiple dimensions. Accordingly, this study will use an analytical framework that draws on digital divide studies like Sarkar, Pick, and Johnson (2015), Kayisire and Wei (2016), and Chen (2021) to construct a set of dimensions by which to evaluate mobile internet adoption in sub-Saharan Africa. The present study extends on existing studies by combining a unique set of variables into a widely used framework. Drawing on the framework, this study examines three sets of determining factors of mobile internet adoption:

a) physical infrastructure (electricity access),

b) socioeconomic factors (income level, urban or rural location, age, and education level), and
c) perspective factors shaped by network effects (time spent face-to-face with interest groups and number of close friends on social media platforms).

3.3.3 Measurement and definition of variables

3.3.3.1 Dependent variables

The dependent variable of mobile internet adoption is a binary variable, where 1 = Yes (respondent has used the internet) and 0 = No (respondent has not used the internet).

3.3.3.2 Independent variables

The variable of electricity access $\beta_1 electricity\_access_i$ is created by using a respondent's answer to source of electricity and transforming the electricity access variable into a binary variable where 1 = Electricity access (by combining all sources of electricity) and 0 = No electricity access. The expectation is that there will be a positive relationship between electricity access and mobile internet adoption in Nigeria and Kenya. Since South Africa has universal electricity access, the expectation is that there will be no relationship between electricity access and mobile internet adoption.

In line with contemporary studies like Forenbacher et al (2019), who used disposable income, Chen (2021) who used the value of monthly income, the current study will use total monthly income for the income variable $\beta_2 income_i$. The expectation is that mobile internet adoption will be associated with higher income levels. For their age variable, Forenbacher et al (2019) used age in years. Although some studies (Chen, 2021; Hasbi & Dubus, 2020) used age categories (young people, middle-aged people, and elderly people) the current study will use age in years for the age variable $\beta_4 age_i$, similar to Forenbacher. The expectation is that mobile internet adoption will be associated with younger age groups.

The education variable $\beta_5 educ_i$ is a categorical variable created by obtaining respondents' highest level of education and ordering the responses according to four levels of education: No education (1), primary education (2), secondary education (3), and tertiary education (4). This is consistent with studies like Forenbacher et al (2019) and Hasbi and Dubus (2020). The expectation is that mobile internet adoption is associated with higher levels of education in Kenya and Nigeria, while this might not be the case for South Africa, given the country's high levels of internet adoption and relatively low tertiary education level. Location variable

$\beta_3 urban_i$ is a binary variable where 1 indicates that a respondent lives in an urban area and 0 indicates rural location. The expectation is that mobile internet adoption is associated with urban dwellers in South Africa and Kenya, while it is expected to be associated with rural dwellers in Nigeria, given the latter's large rural population.

The social engagement variable $\beta_6 interest\_groups_i$ is created by converting the number of hours a respondent spends interacting with interest groups like religious, sports, or cultural groups into a binary variable where 0 = no social engagement (respondent spends no time in a week on interest groups) while 1 = social engagement, (respondent indicated some time (> 0) spent face-to-face with interest groups each week). The expectation is that mobile internet adoption will be associated with socially engaged individuals. The social media variable $\beta_7 social\_media\_friends_i$ ranges from 0-5, based on how many of the respondent's close friends (five closest friends) use a social network platform like Facebook or Twitter. The expectation is that mobile internet adoption will be associated with more close friends on social media. Finally, ε_i is an error term clustered at the country level.

Table 1 shows the dependent and independent variables that will be used.

Table 1: Data description

Variable	**Definition**	**Hypothesised relationship**
Dependent variable		
Mobile internet	Accessing the internet through a smartphone or feature phone (1 = yes, 0 = no)	
Infrastructure variables		
Electricity access	1 = Electricity access at home 0 = No electricity	None/Positive
Socioeconomic variables		
Total monthly income	Total monthly income in local currency	Positive
Location	1 = Individual resides in urban or peri-urban area 0 = Individual resides in rural area	Positive/Negative
Age	Age in years	Negative
Education level (1–4)	Respondent's highest level of education, 2017 1 = No formal education 2 = Primary education 3 = Secondary education 4 = Tertiary education (Diploma/Certificate, Bachelors, Masters, PhD, or vocational training)	Positive /Negative

Social network effects		
Social engagement	1= Socially engaged (spends face-to-face time each week with interest groups – religious, political, sports) 0 = Not socially engaged	Positive
Close friend (0–5)	The number (up to 5) of the respondents' closest friends who use an online social network like Facebook or Twitter (0 refers to no close friend and 5 refers to all five closest friends)	Positive

To answer the second, third, and fourth, research questions (What is the impact of physical infrastructure, socioeconomic factors, and perspective factors, respectively on mobile internet adoption?) simplified models of the above regression model are constructed to determine the impact of the variables in each dimension on mobile internet adoption.

3.3.4 Data analysis

To analyse each variable for the three countries selected, the study employs descriptive statistics such as the mean and the mode (measures of central tendency) as well as range and standard deviation (measures of variation). The variables are analysed individually and collectively to construct a picture of each country's overall and internet user population. Regression analysis is used by combining the variables and for each country to a) identify the most significant drivers of mobile internet adoption, b) identify the impact of physical infrastructure variables on internet adoption, c) identify the impact of socioeconomic factors on internet adoption, and d) identify the impact of perspective factors on internet adoption.

3.3.5 Research criteria

The data compiled by Research ICT Africa have been used in prior studies and have been found to be accurate, reliable, and representative of the respective countries. The Research ICT Africa data shows 1,815 observations for South Africa, 1,208 for Kenya, and 1,808 for Nigeria. Validity and reliability were ensured by comparing survey data to industry statistics and ensuring that these were within reasonable proximity. Furthermore, reliability and validity will be ensured by using the same data source for all three countries.

Missing values were eliminated by using a discretionary approach. No missing values were found for any of the variables for Kenya and Nigeria. In the case of South Africa, missing values for mobile internet adoption were assumed to indicate unconnected users, since the

number of missing values correspond with the number of respondents who indicated that they do not know what the internet is. Two missing values were found for the age variable. These were assigned South Africa's mean age of 42. For the education variable, all 1,815 values were missing for South Africa, implying that respondents did not complete the specific question that asks for their education level. All respondents did, however, complete the question about the highest education level of any household member, which is used as a proxy for education level.

3.4 Research limitations

For this paper to provide relevant findings to inform policy makers, it is important that the empirical tests performed capture and produce accurate results. By making use of secondary data from another source, this study is inherently limited by the congruence of how survey questions were asked and answered across the region. Furthermore, insights are limited to 2017 and 2018. As is the case with many studies based on African samples, there is a shortage of frequent data series over a long period needed to paint a detailed picture, over time. Nonetheless, the methodology applied in this study is uniform across countries, and consistent with existing literature.

The results presented in this study are associational, or correlational; not causal. Since no instrumental variable approach was utilised to conduct a causality test, potential endogeneity in the estimated model must be acknowledged.

Chapter 4: Discussion of Findings

4.1 Introduction

This chapter presents the research findings of the quantitative analysis on the determinants of mobile internet adoption in Kenya, Nigeria, and South Africa in 2017-2018. The research findings include descriptive statistics for all the dependent and independent variables that will be used to determine the most significant determinants of mobile internet adoption, and the results from the regression analysis.

The results from the regression models specified in the previous chapter are analysed and interpreted to provide accurate and meaningful policy recommendations. The analytical framework through which the results are analysed and interpreted is shaped by the research questions and the hypotheses that have been developed for each of these in the preceding chapters.

4.2 Description of data

Table 2 provides a summary of the descriptive statistics for the variables for Kenya, Nigeria, and South Africa.

Table 2: Descriptive statistics

Kenya					
Variable	**Observations**	**Mean**	**Std. dev.**	**Min**	**Max**
mobile_internet	1,208	.3642384	.4814153	0	1
electricity_access	1,208	.7516556	.4322315	0	1
total_income	1,208	28011.52	97829.45	100	960000
location	1,208	.6018212	.4897254	0	1
age	1,208	33.58692	12.68851	15	86
educationlevel	1,208	.8195364	.3847324	1	4
social_media_friends	1,208	2.23096	2.022361	0	5
social_engagement	1,208	.8195364	.3847324	0	1
Nigeria					
Variable	**Observations**	**Mean**	**Std. dev.**	**Min**	**Max**
mobile_internet	1,808	.2970133	.4570689	0	1
electricity_access	1,808	.7997788	.4002765	0	1
total_income	1,808	31049.11	50143.6	1	680000
location	1,808	.4280973	.4949399	0	1
age	1,808	35.26936	15.75595	1	99
educationlevel	1,808	2.489491	1.028052	1	4
social_media_friends	1,808	1.495575	2.052165	0	5
social_engagement	1,808	.8545354	.3526662	0	1
South Africa					
Variable	**Observations**	**Mean**	**Std. dev.**	**Min**	**Max**
mobile_internet	1,815	.4567493	.4982631	0	1
electricity_access	1,815	.9327824	.2504675	0	1
total_income	1,815	4027.754	8511.116	0	140000
location	1,815	.5785124	.4939334	0	1
age	1,815	41.70799	17.78828	15	98
educationlevel	1,815	3.060055	.7068939	1	4
social_media_friends	1,815	1.945455	2.21347	0	5
social_engagement	1,815	.6247934	.4843097	0	1

In terms of mobile internet adoption in each country, the data show that 46% of South Africans are connected, compared to 36% of the Kenyan population, and 30% in Nigeria, as illustrated in Figure 1.

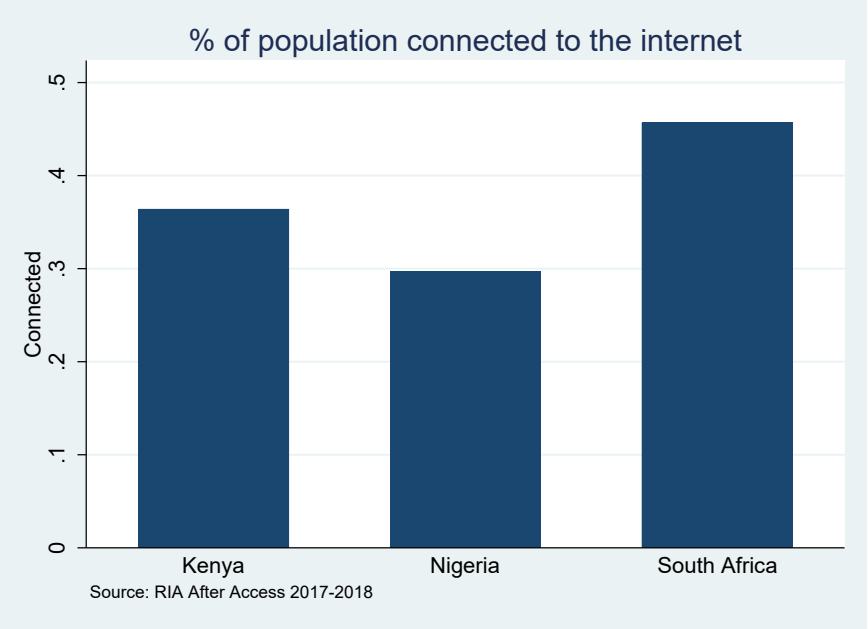

Figure 1: Proportion of population connected.

In terms of electricity access, the data show that 93% of South Africans have electricity access, compared to 75% in Kenya and 80% in Nigeria. Figure 2 shows the detailed household electricity source for the three countries.

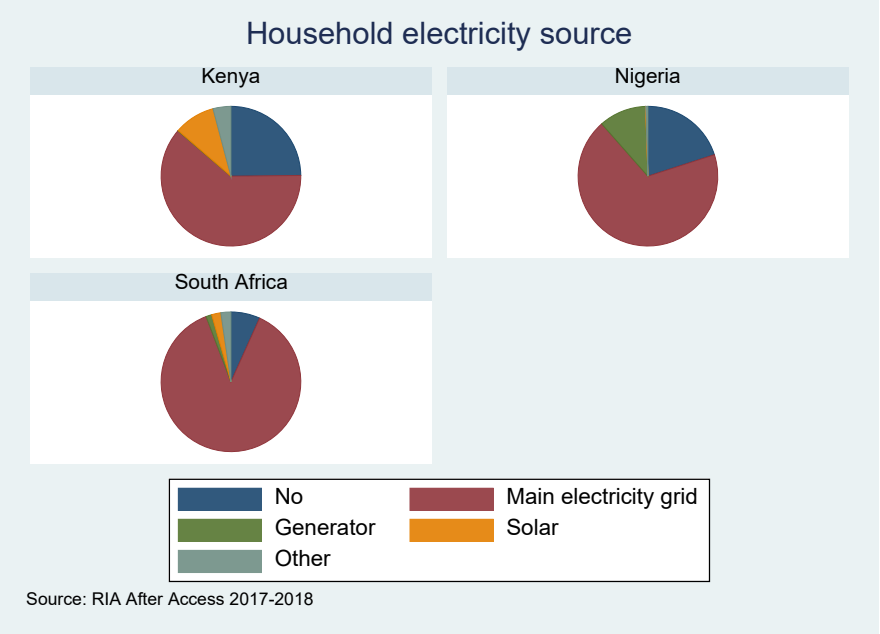

Figure 2: Household electricity source.

Looking at income levels, the average total monthly income is roughly R4,000 (US$308) in South Africa, KSh28,000 (US$266) in Kenya, and ₦31,000 (US$87) in Nigeria, according to the Research ICT Africa data and 2017 exchange rates. Figure 3 shows the comparison of average monthly income in US$.

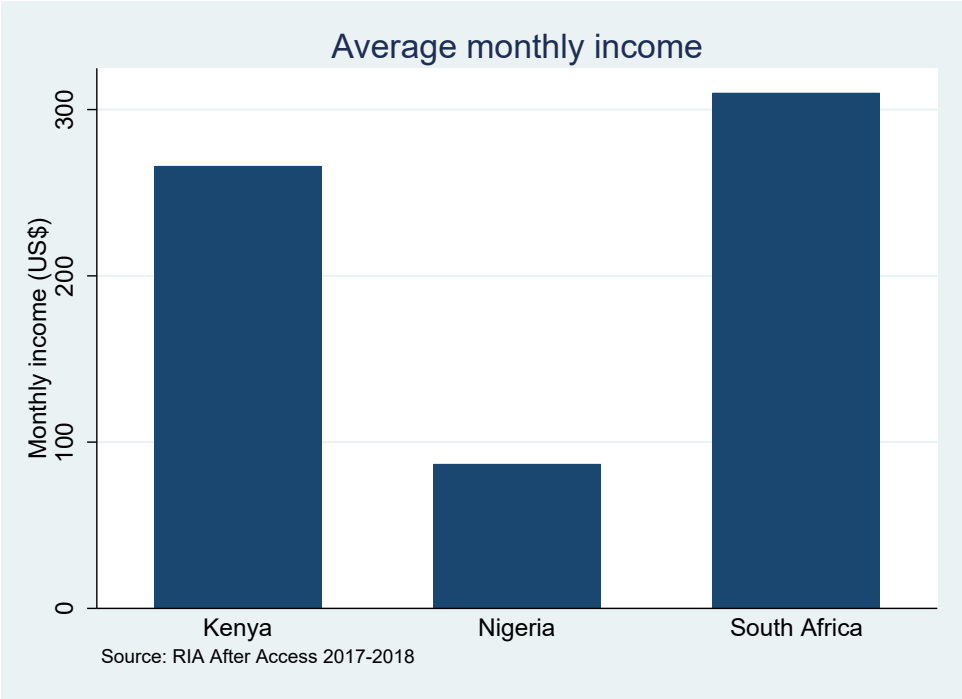

Figure 3: Average monthly income (US$).

In terms of location, 58% of South Africans are located in urban areas, while that number is 60% in Kenya and 43% in Nigeria, as illustrated in Figure 4.

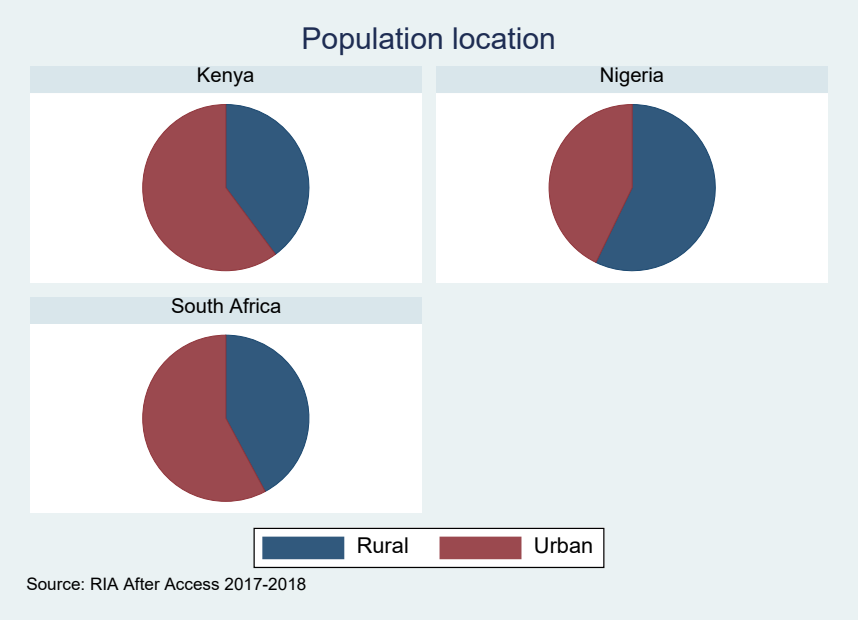

Figure 4: Urbanisation.

In terms of education, in Kenya, 30% of household members has tertiary education or equivalent, compared to 27% in Nigeria and 25% in South Africa. A detailed comparison of education level across the countries is illustrated in Figure 5.

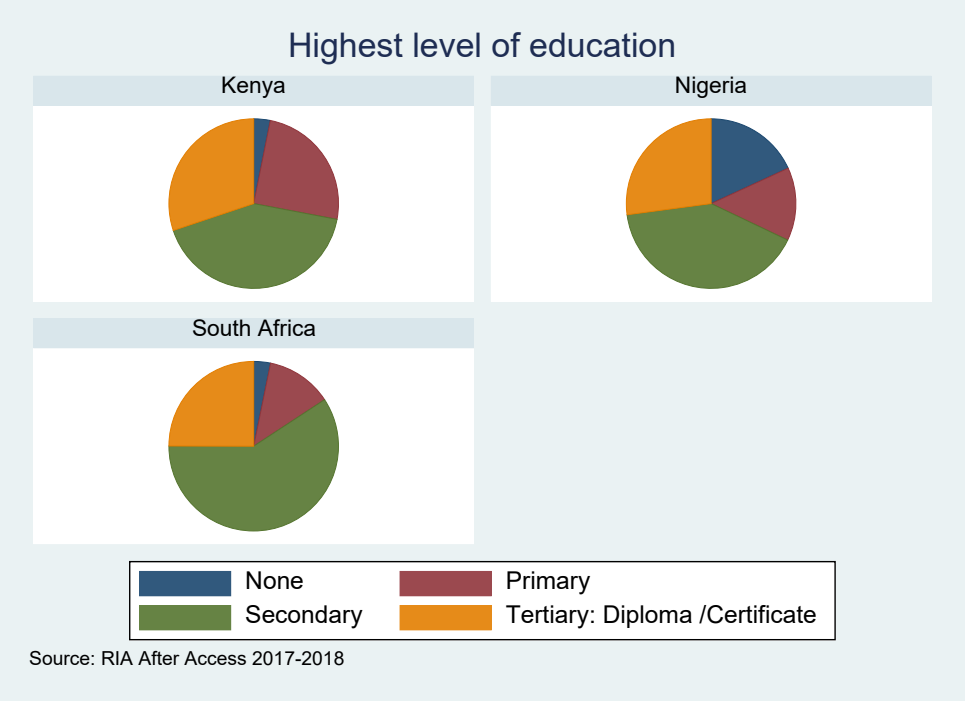

Figure 5: Highest level of education.

The data show that South Africa has the oldest population at an average age of 42, followed by Nigeria (35) and Kenya (34). Along the perspective dimension, the data show that Kenyans (2.2) on average have more close friends on social media than South Africans (2) or Nigerians (1.5), while more Nigerians (86%) and Kenyans (82%) tend to be socially engaged in interest groups related to sports, culture or religion than South Africans (63%).

The descriptive statistics show that of the countries selected, South Africa has the highest rate of internet adoption. South Africa has the highest rate of electricity access and level of income. Most South Africans live in urban areas and 25% (the lowest rate of the three countries) have tertiary education. Kenya has the second highest level of internet connection. The country's electricity access is the lowest of the three countries, its tertiary education level is the highest, and it boasts the second highest level of income. Most citizens live in urban areas. Nigeria has the lowest level of internet connectivity. The country has a slightly higher level of electricity access than Kenya. Nigeria has by far the lowest level of income and much of the population are rural dwellers. Interestingly, tertiary education is higher in Nigeria than in South Africa.

4.3 Regression Results

A log regression model was run to determine the most significant determinants of mobile internet adoption in Africa, considering all other variables. The most significant determinant of internet adoption across all three countries is education level. In Kenya and South Africa, the likelihood of being connected is 2.8- and 2.7-times higher for someone with a tertiary education compared to someone with secondary education, respectively. This relationship is even more pronounced in Nigeria, where someone with tertiary education is 3.7-times more likely to be connected, compared to someone with secondary education.

In terms of the physical access dimension of internet adoption, the hypothesis was that electricity access would not be significantly correlated to mobile internet adoption in South Africa and that it would be positively correlated to internet adoption in Nigeria and Kenya. Even though the expectation was that electricity access would not be statistically significant regarding internet adoption in South Africa, those with electricity access were found to be 2.4-times more likely to be connected than those without electricity access. In Nigeria, those with access to electricity were almost 2-times more likely to be internet users, in line with the hypothesis. However, electricity access was not statistically significant for internet adoption in Kenya.

In terms of the socioeconomic dimension of internet adoption, the variable, education level, was found to be the most significant determinant of internet adoption across all three countries. The hypothesis was that the variable of tertiary education will increase the probability of internet adoption for Nigeria and Kenya and will decrease the probability of internet adoption for South Africa. The hypothesis was that the income variable will increase the probability of internet adoption for Nigeria, Kenya, and South Africa. Although it was expected that income would be a significant determinant of internet adoption, it was not identified as a strong determinant for any of the countries. The hypothesis was that the variable of age will decrease the probability of internet adoption for Nigeria, Kenya, and South Africa. However, age was not statistically significant for any of the countries. The hypothesis was that the variable of being an urban dweller will increase the probability of internet adoption for Kenya and South Africa, and decrease the probability of internet adoption for Nigeria. While location was not statistically significant for Kenya or Nigeria, urban South Africans are almost 1.8-times more likely to be connected to the internet than rural dwellers, confirming the hypothesis for this country. Hence, across all three countries, ‘education level’ is the strongest socioeconomic

determinant of internet adoption, while income and age did not predict internet adoption, and location is a significant determinant of internet adoption only in South Africa.

In terms of the perspective dimension of internet adoption, the hypothesis was that the variable of close friends on social media and the variable of time spent face-to-face with interest groups (cultural, religious, sports) will increase the probability of internet adoption for all three countries. Having close friends on social media was found to be a strong determinant of being connected, for all of the countries, confirming the first half of the hypothesis. For each additional close friend on social media, respondents were 84% more likely to be connected in Kenya, twice as likely to be connected in Nigeria, and 51% more likely to be connected in South Africa. Although social engagement was expected to increase the likelihood of being connected to the internet, this determinant was only statistically significant in South Africa, where social engagement increased the likelihood of being connected by 34%.

The number of observations for each of the three logistic regression results corresponded with the number of observations for each country, indicating that there were no missing values. For all three countries, the overall model was statistically significant, indicated by the probability of obtaining the chi-square statistic if there is no effect of the independent variables taken together on the dependent variable, or p-value, of less than 0.000. The pseudo R-squared was 0.4555 for Kenya, 0.5271 for Nigeria, and 0.4076 for South Africa. As such, the model can be said to be robust for all three countries. See Tables 3-5 for more detail of the regression output.

Table 3: Logistic regression output for Kenya, Nigeria and South Africa

	KENYA			NIGERIA			SOUTH AFRICA		
	Odds ratio	**SE**	**z**	**Odds ratio**	**SE**	**z**	**Odds ratio**	**SE**	**z**
Constant	0.0140			0.0066			0.0332		
Physical access									
Electricity access	1.6337*	0.4542	1.77	1.9673	0.6721**	1.98	2.3555	0.6899***	2.93
Socioeconomic factors									
Income	1.0000***	0.0000	4.09	1.0000	0.0000	-0.19	1.0001	0.0000***	6.24
Location	1.1586	0.2542	0.67	1.1000	0.1838	0.57	1.7873	0.2470***	4.2
Age	0.9413***	0.0099	-5.72	0.9570	0.0072***	-5.84	0.9412	0.0045***	-12.77
Education level	2.8274***	0.4161	7.06	3.6906	0.4836***	9.97	2.7284	0.3528***	7.76
Perspective factors									
Friends on social media	1.8440***	0.0978	11.54	2.0325	0.0852***	16.92	1.5140	0.0479***	13.11
Social engagement	0.8952	0.2313	-0.43	0.7660	0.2253	-0.91	1.3373	0.1813**	2.14
Number of observations	1,208	1,208		1,808	1,808		1,815	1,815	
Pseudo R2	0.4555	0.4555		0.5271	0.5271		0.4076	0.4076	

Note:***, ** & * denote significance at 1%, 5% and 10% respectively.

What is the impact of infrastructure variables on mobile internet adoption in Africa?

In terms of the physical access dimension of internet adoption, the hypothesis was that electricity access would not have a significant impact on the probability of mobile internet adoption in South Africa and that it would be positively correlated to internet adoption in Nigeria and Kenya. By analysing the physical infrastructure dimension in isolation, the results show that electricity access has a significant positive impact on the probability of mobile internet adoption in all three countries.

For all three countries, the overall model was statistically significant, indicated by the probability of obtaining the chi-square statistic if there is no effect of the independent variables taken together on the dependent variable, or p-value, of less than 0.000. However, the model (analysing only the physical infrastructure dimension to predict mobile internet adoption) is not robust for any of the three countries, indicated by low pseudo R-squared outputs of 0.0805, 0.0767 and 0.0188 for Kenya, Nigeria, and South Africa, respectively, echoing the literature that the digital divide cannot be explained by physical infrastructure factors alone. See Tables 6-8 for more detail of the regression output.

Table 4: Logistic regression output for physical infrastructure dimension for Kenya, Nigeria and South Africa

	KENYA		**NIGERIA**		**SOUTH AFRICA**	
	Odds ratio	SE	Odds ratio	SE	Odds ratio	SE
Physical access						
Electricity access	6.5729***	1.2897	10.6998***	2.6528	4.3911***	1.0746
Observations	1,208	1,208	1,808	1,808	1,815	1,815
Pseudo R2	0.0805	0.0805	0.0767	0.0767	0.0188	0.0188

Note: *** denotes significance at 1%

What is the impact of the socioeconomic variables on mobile internet adoption in Africa?

In terms of the socioeconomic dimension of internet adoption, the hypotheses were:

- The variable of total income will increase the probability of internet adoption for Nigeria, Kenya, and South Africa;
- the variable of age will decrease the probability of internet adoption for Nigeria, Kenya, and South Africa;
- the variable of being an urban dweller will increase the probability of internet adoption for Kenya and South Africa however,

- the variable of being an urban dweller will decrease the probability of internet adoption for Nigeria;
- the variable of tertiary education will increase the probability of internet adoption for Nigeria, and Kenya.; and
- the variable of tertiary education will decrease the probability of internet adoption for South Africa.

Although income is statistically significant and increases the probability of mobile internet adoption in all three countries (confirming the hypothesis), the relationship is not robust. Similarly, higher age is associated with a lower probability of mobile internet adoption in all three countries, in line with the hypothesis that younger people will be associated with mobile internet usage. For every year, someone is 7% less likely to be an internet user in Kenya and South Africa, and 5% less likely in Nigeria. Compared to the other variables, however, age is not a significant contributor to mobile internet adoption in these countries.

Urban location, on the other hand, when analysed through the socioeconomic dimension, significantly contributes to the probability of mobile internet adoption in all three countries, even though it was hypothesised that urban location would be associated with a lower probability of mobile internet adoption in Nigeria. In all three countries, urban residents are roughly twice as likely as rural dwellers to be internet users. Similarly, education level increases the likelihood of internet adoption significantly in all three countries, even though it was hypothesised that it would decrease the probability of internet adoption in South Africa, given the country's relatively higher internet penetration and lower tertiary education level. In all three countries, the likelihood of being connected is 3 - 4 times higher for those with tertiary education than those with secondary education.

For all three countries, the overall model was statistically significant, indicated by the probability of obtaining the chi-square statistic if there is no effect of the independent variables taken together on the dependent variable, or p-value, of less than 0.000. Furthermore, the model (analysing only the socioeconomic dimension to predict mobile internet adoption) is robust for all three countries, indicated by the pseudo R-squared outputs of 0.3115, 0.2640 and 0.3218, confirming the importance of socioeconomic factors in determining mobile internet adoption as highlighted in the literature. See Tables 9-11 for more detail of the regression output.

Table 5: Logistic regression output for socioeconomic dimension for Kenya, Nigeria and South Africa

	KENYA		NIGERIA		SOUTH AFRICA	
	Odds ratio	**SE**	**Odds ratio**	**SE**	**Odds ratio**	**SE**
Socioeconomic factors						
Constant	0.0478		0.0177		0.0940	
Income	1.0000***	0.0000	1.0000***	0.0000	1.0002***	0.0000
Location	2.1793***	0.3744	1.8443***	0.2268	2.1310***	0.2695
Age	0.9267***	0.0086	0.9518***	0.0051	0.9306***	0.0041
Education level	3.2837***	0.3885	4.0647***	0.3723	3.7212***	0.4433
Observations	1,208	1,208	1,808	1,808	1,815	1,815
Pseudo R2	0.3115	0.3115	0.264	0.264	0.3218	0.3218

Note: *** denotes significance at 1%

What is the impact of the network effect of spending time with interest groups, or having more than five close friends on a social network, on mobile internet adoption in Africa?

In terms of the perspective dimension of internet adoption, the hypothesis was that the variable of close friends on social media and the variable of time spent face-to-face with interest groups (cultural, religious, sports) will increase the probability of internet adoption for Nigeria, Kenya, and South Africa. Having close friends on social media was found to be a strong determinant of being connected across all three countries. When analysing mobile internet adoption through the perspective dimension alone, for each additional close friend on social media, respondents were more than twice as likely to be connected in Kenya, 2.5-times as likely to be connected in Nigeria, and almost twice as likely to be connected in South Africa. Although social engagement was expected to increase the likelihood of being connected to the internet, this variable *decreased* the likelihood of being connected in Kenya. In Nigeria and South Africa, social engagement *increased* the likelihood of being connected by 24% and 33%, respectively.

However, these results were not statistically significant for any of the countries. This complicates the statistical significance of analysing mobile internet adoption by utilising the perspective dimension alone. The overall model was statistically significant, indicated by the probability of obtaining the chi-square statistic if there is no effect of the independent variables taken together on the dependent variable, or p-value, of less than 0.000. Furthermore, the model (analysing only the perspective dimension to predict mobile internet adoption) is robust for all three countries, indicated by the pseudo R-squared outputs of 0.3464, 0.4493 and 0.2684,

confirming the importance of perspective factors in determining mobile internet adoption as highlighted in the literature. See Tables 12-14 for more detail of the regression output.

Table 6: Logistic regression output for perspective dimension for Kenya, Nigeria and South Africa

	KENYA		NIGERIA		SOUTH AFRICA	
	Odds ratio	SE	Odds ratio	SE	Odds ratio	SE
Perspective factors						
Friends on social media	2.3478***	0.1092	2.5117	0.0970***	1.8707***	0.0526
Social engagement	0.9243	0.2190	1.2445	0.3207	1.3315**	0.1613
Constant	0.0652		0.0572		0.2095	
Number of observations	1,208	1,208	1,808	1,808	1,815	1,815
R2						
Pseudo R2	0.3464	0.3464	0.4493	0.4493	0.2684	0.2684

Note: *** & ** denote denotes significance at 1% & 5% respectively.

Chapter 5: Conclusion and Recommendations

5.1 Introduction

This study examined the most significant determinants of mobile internet adoption in Kenya, Nigeria, and South Africa. This chapter presents a summary of the study conducted as well as conclusion based on the findings. It also provides policy recommendations and recommendations for future studies based on limitations encountered in this study.

5.2 Summary of findings and conclusion

If benefits of internet usage among households in sub-Saharan Africa are to be unlocked, and if, with this unlocking there is the subsequent injection of money and talent into the continent's digital economy, it is crucial to identify the key constraints faced by individuals in adopting internet services. While technology has reshaped the economic landscape over the past decade, this disruptive sector has also contributed to existing economic and social inequalities between 'connected' and 'unconnected' countries and individuals. For technology to fulfil its economic and social potential (creating jobs, access to health, and so on), the foundation for a digital economy must be in place: digital infrastructure, basic and higher education, digital literacy and skills, social platforms, financial services, and entrepreneurial innovation (Google and IFC, 2020).

Many studies on the digital divide and ICT adoption in Africa have used the approach of defining the digital divide along multiple dimensions. Accordingly, this study also used a conceptual model that drew on digital divide studies like Sarkar, Pick, and Johnson (2015) and Kayisire and Wei (2016) to construct a set of dimensions by which to evaluate mobile internet adoption in sub-Saharan Africa. Drawing on a framework that has been widely used in the digital divide literature, the study examined three unique sets of determining factors of mobile internet adoption: a) physical infrastructure (electricity supply); socioeconomic factors (income level, urban or rural location, age, and education level, and c) perspective factors (number of close friends on social media platforms and face-to-face time with interest groups) shaped by network effects.

This study sought to a) examine how physical infrastructure, socioeconomic variables, and perspective factors affect mobile internet adoption in Africa, and b) compare differences in

mobile internet adoption across different countries and demographic profiles in the region, from the demand-side. The study adds to the existing literature in the following ways: a) It is one of the first studies to investigate the determinants of *mobile* internet adoption in Africa; b) it used nationally representative household-level data that follow a consistent methodology across the continent, allowing cross-country comparisons – a rarity in the literature; and c) it aimed to establish significant relationships between both supply-side and demand-side variables and mobile internet adoption, which could help policymakers in the region.

In summary of the study conducted, the most significant determinant of internet adoption across all three countries is education level. In Kenya and South Africa, the likelihood of being connected is 2.8- and 2.7-times higher for someone with a tertiary education compared to someone with secondary education, respectively. In Nigeria, someone with tertiary education is 3.7-times more likely to be connected compared to someone with secondary education. This finding supports the theoretical literature and empirical literature, including previous studies like Szeles (2018), who contend that more educated individuals tend to be more inclined to use and adopt ICT, and Srinuan and Bohlin (2011), who have shown that education can be instrumental in bridging the digital divide. African countries' relatively low-quality education systems, high rates of illiteracy, and low rates of digital skills could explain the region's low internet adoption rate and increasing rates of tertiary education could help catalyse internet adoption and meaningful participation in the digital economy, over the coming years.

In terms of the physical access dimension of internet adoption, even though the expectation was that electricity access would not have a significant effect on internet adoption in South Africa, those with electricity access were found to be 2.4-times more likely to be connected than those without electricity access. In Nigeria, those with access to electricity were almost twice as likely to be internet users, while electricity access was not statistically significant for internet adoption in Kenya. The importance of electricity access for internet adoption in South Africa and Nigeria supports the theory of technological determinism, the supply-side driven theory that contends that greater ICT infrastructure (in the case of mobile internet, 3G coverage and above) should lead to greater adoption of ICT technology, including mobile internet technology.

Limited access to reliable electricity limits the development of digital infrastructure. Electricity is needed to power mobile internet connectivity, from recharging a mobile device to powering a mobile base station. The finding supports digital divide studies in Africa that have found that

the availability of electricity and other infrastructure have been crucial for ICT development and adoption on a region- and country-level (Sarkar, Pick, and Johnson, 2015 an example of such studies). The household electrification rate in sub-Saharan Africa is the lowest in the world at 47.9% in 2019, compared to 90% globally (IEA, 2020), clearly hampering connection to the internet and participation in the digital economy. Promisingly, though, US$36.8 billion was invested in electricity infrastructure in sub-Saharan Africa between 2010 and 2019, more than 72% of infrastructure investment with private participation in the region (The World Bank Group, 2020). The expectation is that as electricity access spreads across the region, the social and economic opportunities will benefit Africa's people exponentially, including those offered by the digital economy.

Although it was expected that income would be a significant determinant of internet adoption, it was not identified as a strong determinant for any of the countries. This contradicts the theory that higher-income countries have higher levels of technology adoption and narrower digital divides than lower-income countries. It also contradicts the findings that digital exclusion in Africa is primarily an issue of poverty (Gillwald & Mothobi, 2019). However, South Africa, with the highest level of income of the three countries studied, also has the highest internet penetration.

While location was expected to impact mobile internet adoption across the region, location was not statistically significant for Kenya or Nigeria, two countries with very different levels of urbanisation. This contradicts findings that the urban-rural divide is significant across all developing regions, particularly in Africa, where the urban mobile internet adoption rate is more than twice that of rural dwellers (Chen, 2021). Individuals in urban environments access ICTs such as mobile broadband, more easily and cheaply, and these large and dense populations reduce the cost of rolling out and adopting ICT, thus increasing penetration. However, in South Africa, urban dwellers are almost 1.8-times more likely to be connected to the internet than rural dwellers. This reflects the realities of the country, where mobile broadband covers more than 95% of the population, but less than half of rural dwellers are connected to the internet.

Age was found not to be a strong predictor of mobile internet adoption in any of the countries, which supports studies like Forenbacher et al (2019), who found that age had a negative effect on mobile phone ownership in Nigeria, but that other variables like income, employment status, and education level, could paint a more complete picture. Many studies show that older people

are less likely to adopt new technologies than teenagers (Billon et al., 2009; Srinuan & Bohlin, 2011) and more likely to cite reasons for avoiding new technologies (van Deursen & van Dijk, 2011).

The multi-perspective approach of the digital divide supports the theory of social determinism, according to which a particular society is responsible for the development and deployment of technology, and the way any technology is used in a society or culture reflects that society or culture. This was proven correct, based on the dispersion of findings across the three countries. Perspective factors include network effects arising from membership in religious, cultural, economic, and other communities (Mwin & Kritzinger, 2016; Srinuan & Bohlin, 2011). Studies suggest that being a member of the same group or community can motivate people to adopt certain ICTs because of network effects.

In terms of the perspective dimension of internet adoption, having close friends on social media was found to be a strong determinant of being connected to the internet across all three countries. For each additional close friend on social media, respondents were 84% more likely to be connected in Kenya, twice as likely to be connected in Nigeria, and 51% more likely to be connected in South Africa. This supports the findings from studies like Chen (2021), who found that social network effects have a significant positive impact on mobile internet usage in developing countries, and Hasbi and Dubus (2020), who provided evidence that being part of an online social community has a positive impact on mobile broadband use in sub-Saharan Africa. Although social engagement was expected to increase the likelihood of being connected to the internet, this determinant was only statistically significant in South Africa, where social engagement increased the likelihood of being connected to the internet by 34%, and even decreased the probability of mobile internet adoption in Kenya. One explanation could be that those who are socially engaged use face-to-face opportunities to socialise, as opposed to using online social media platforms. The perspective dimension shows that the uptake of mobile internet and participation in the digital economy is driven more by friends' online activity than face-to-face social engagement.

Given the multifaceted nature of the digital divide – particularly as it relates to internet access and usage – the digital divide literature suggests that multiple dimensions of determinant factors should be considered. As the digital divide has widened over time despite expanding service coverage everywhere, it became clear that the gap could not be explained by the

dimension of access (supply-side factors) alone. This study confirmed that a multidimensional approach should be taken to determine the key drivers of mobile internet adoption in Africa.

Additionally, the diffusion of innovations theory contends that the speed at which a technology spreads is informed by people's perception of that technology (Everett, 2003). The descriptive statistics show that of the countries selected, South Africa has the highest rate of internet adoption. South Africa has the highest rate of electricity access, and level of income. Most South Africans live in urban areas and 25% (the lowest rate of the three countries) have tertiary education. Kenya has the second highest level of internet connection. The country's electricity access is lower than South Africa and Nigeria. The country boasts the second-highest level of income and the highest level of tertiary education, and most citizens are located in urban areas. Nigeria has the lowest level of internet connectivity. The country has a slightly higher level of electricity access than Kenya. Nigeria has by far the lowest level of income and the majority of the population are rural dwellers. Interestingly, tertiary education is higher in Nigeria than in South Africa. The expectation was that the determinants of internet adoption in countries that have passed the 20% penetration threshold need to benefit from the technological network effects, will be different to those in countries that have not reached this threshold. The determinants were expected to vary among these countries: South Africa, which is at the late-adopters stage – will be different to Kenya and Nigeria who have passed the 20% threshold and are at the early majority stage. The most significant determinants for South Africa are electricity access, urban location, and level of education. The most significant determinants of mobile internet adoption in Kenya and Nigeria are education level, electricity access, and having many close friends on social media.

5.3 Policy recommendations

The findings should be considered in the context of the three countries – South Africa, Kenya, and Nigeria – having different socioeconomic characteristics and levels of internet adoption. South Africa has higher average monthly income than Kenya and Nigeria and also boasts higher levels of internet adoption. In South Africa, electricity access, education level, urban location, close friends on social media, and face-to-face social engagement were identified as significantly associated with internet adoption. In Kenya, which has passed the 20% internet penetration threshold but has not reached the advanced levels of South Africa, only education level and having close friends on social media was significantly associated with internet

adoption. In Nigeria, with internet penetration at a similar level to Kenya and the lowest average monthly income among the three countries, internet adoption is associated with electricity access, education, and having close friends on social media.

Given that electricity access, education, and having close friends on social media have been identified as potential determinants of internet adoption across the three countries, policymakers in sub-Saharan Africa should consider these aspects when drafting policy to increase internet adoption and participation in the digital economy. African policy makers should focus on investment in electricity supply infrastructure, particularly in countries where electricity access is not universal yet, and education, specifically tertiary education and platforms that provide citizens with the digital skills required to benefit from internet usage. Policy should also encourage the use of social media platforms to attract those still unconnected to the internet.

The results from this study clearly show that providing more citizens with access to electricity will increase internet adoption levels and catalyse the digital economy. The importance of education for internet adoption shows that online applications that cater for those with tertiary education should be prioritised and present potentially lucrative investment opportunities. These include career networking platforms like LinkedIn and online executive education providers, GetSmarter as an example. The impact of network effects of those already on social media platforms presents an opportunity to incentivise those on social media platforms to invite friends to join the platform.

5.4 Avenues for future research

Although the Research ICT Africa data provide invaluable insight into the determinants of internet adoption across the continent, the COVID-19 pandemic and subsequent lockdowns have undoubtably affected African countries' adoption of, and interaction with, mobile phones and mobile internet. More recent data would provide insight into these developments. A longitudinal analysis of mobile internet adoption in Africa would also provide insight into how digital behaviour is changing over time.

Investigating the determinants of adopting the internet helps policymakers to connect more people and inject money into Africa's digital economy. However, research into the online activity (sites visited, time spent online, activities performed) of those already online could

provide even more insight on how to get more people online and, for those already online, participate more actively in the digital economy. This would extend the literature beyond access and adoption of mobile internet to usage of the technology. Given the ever-evolving nature of technology, it might also be useful to investigate if there are any new technologies, platforms, and factors that researchers need to consider when studying participation in Africa's digital economy. These could include trade openness, broadband agreements among countries, and the ease of doing business in a country.

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