Digital Infrastructure and Local Economic Growth
Early Internet in Sub-Saharan Africa

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Abstract

We study whether low-speed internet availability fosters local economic growth in rural areas of developing countries by analyzing remote towns in Sub-Saharan Africa. We measure local economic growth of each town by tracking nighttime light emissions. In a difference-in-differences setting, we exploit exogenous countrywide shocks to internet availability induced by submarine cable arrivals in the 2000s and use the rollout of national inter-regional fiber cables to identify towns incidentally connected early. We find that internet availability induces economic growth. Compared to a control group of similar but later connected towns, connected towns experience 11 percent higher light intensity, which translates to 3.3 percentage points higher annual economic growth in the years after internet connection. Additional results suggest this is mainly driven by per-capita productivity growth and not by migration into connected towns. The effect is stronger in towns with better access to regional markets and internet availability is associated with a shift from agriculture to manufacturing in regional employment.

Keywords: ICT; development; nighttime light; Africa; growth; cybercafé

JEL-Codes: O33; O18; R11

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1 Introduction

In the last decades, the provision of digital infrastructure enabled widespread access and adoption of the internet in most parts of the world. Evidence shows positive effects of broadband internet availability on individual-level economic performance (see, e.g., Akerman et al., 2015-11-01) and country-level economic growth (see, e.g., Czernich et al., 2011) for developed countries. Hopes are high that internet access fosters regional economic growth in the developing world as well (World Bank, 2016). For example, in Sub-Saharan Africa (SSA), where impulses for economic growth are needed urgently to fight poverty, governments, public-private partnerships, and private consortia alike invest large amounts of money in internet infrastructure projects. However, provision of internet access is complex and costly due to a lack of legacy infrastructure such as fixed-line telephony networks (see, e.g., Williams, 2010).[1] Until 2020, SSA countries invested more than 28 billion USD into their national internet backbone (Hamilton Research, 2020).[2] Despite these enormous digital infrastructure investments, a growth effect of internet in SSA is not assured. Low population density apart from the mega-cities, missing hardware, financial constraints, and a lower willingness to pay lead to low adoption rates (World Bank, 2016). At the same time, the potential of the internet seems particularly high in SSA since alternative ICT is largely absent (ITU, 2019). Given the large investment requirements and unclear economic benefits, it is crucial to understand how internet availability affects regional economic development in SSA, especially in rural areas where provision is particularly costly.

In this paper, we examine whether internet availability causes local economic growth in remote areas of Sub-Saharan Africa and, as a result, contributes to rural development. In contrast to the existing literature, we focus on the extensive margin of internet provision in a developing-country setting featuring low literacy rates and agrarian, labor-intensive economies. Specifically, we study remote towns during the initial introduction of the internet in SSA through the first wave of internet-enabled submarine cables from 1999 until the mid-2000s, enabling low-speed internet connectivity (0.5-2 Mbps). At the time, people accessed the internet predominantly in cybercafés, small community-based internet centers that provide local communities with internet access using minimal infrastructure (see, e.g., Southwood, 2022). We track economic activity at the town level in response to plausibly exogenous shocks in local internet availability. To assess potential mechanisms, we decompose growth of towns into spatial expansion (extensive margin) and density of economic activity (intensive margin) and interpret these components as pointing more toward population or productivity growth, respectively. We corroborate this analysis with an assessment of changes in local population density. In addition, we investigate changes in regional employment shares to study structural transformation associated with internet availability.

[1] Ngari and Petrack (2019) estimates that laying down one kilometer of fiber-optic cable in SSA costs between USD 15,000 and 30,000.

[2] Facebook announced an effort to build a new internet-enabled submarine cable (SMC) to Africa for one billion USD in 2020 (Bloomberg, 2020; Anderson and O'Connor, 2020). China plans to invest more than 60 billion USD in Africa's digital infrastructure as part of its 'Belt and Road' initiative (Invesco, 2019).

Our baseline sample captures the evolution of 210 remote towns in 10 SSA countries provided with (international) internet bandwidth between 1999 and the mid-2000s and a pre-existing national backbone outside larger cities. We tap two main data sources. First, we measure local economic growth, the key outcome of interest, using nighttime light (NTL) intensity captured by satellite, a well-established proxy introduced by Henderson et al. (2011) at the country level and validated by Storeygard (2016) on the city level for SSA. We compute yearly economic activity of each town by assigning NTLs to individual agglomerations via built-up areas from *Africapolis*. Second, we use data on the rollout of national internet infrastructure backbones from Hamilton Research (2020) to measure internet infrastructure availability in each town. The data comprises a comprehensive record of the locations of internet access points in SSA. Because data only starts in 2009, we conduct an extensive review of national backbone deployment projects to assign construction years to access points. This enables us to study the early- and mid-2000s when the first wave of sub-marine cable arrivals brought the internet to SSA for the first time at noticeable scale.

To identify the causal effect of internet availability on local economic growth, we exploit quasi-random variation in the timing of country-wide internet access induced by the arrival of the first wave of sub-marine cables (SMCs) in SSA. This approach was established by Hjort and Poulsen (2019), who exploit an internet speed upgrade induced by the second wave of SMCs with higher capacities. In a difference-in-differences framework, we additionally exploit the national backbone expansion to define comparable treatment and control towns. National backbone expansions aim to connect political and economic centers (Williams, 2010). Importantly, towns located on-route between such 'nodal cities' typically receive access points. We assign treatment status to towns that were connected to the national backbone when the internet became available country-wide, while the control group consists of similarly-sized towns getting internet connection only later. In a fixed effects model with town and country-year fixed effects, we then compare economic growth of towns with backbone access at the time when internet becomes available country-wide for the first time to a control group of similar towns getting access only later. Our key identifying assumption is that treatment and control group towns would have evolved similarly in the absence of treatment. This assumption cannot be tested for, but we estimate a dynamic event-study specification of our model to show that there are no differences in pre-treatment trends of economic activity between treatment and control group towns.

We find that connection to the internet through an access point on average leads to a 11 percent increase in NTL emission of towns in rural SSA in the years after country-wide connection compared to a control group of similar towns not connected through an access point at that time. Applying the established light-to-GDP elasticity from Henderson et al. (2012), this translates into about 3.3 percentage points higher economic growth. We then decompose this overall effect into measures for intensive- and extensive-margin growth and find higher statistical significance for intensive-margin growth, suggesting an increase of per-capita productivity. Together with the fact that we do not find effects on population growth, this points toward economic development rather than a spatial redistribution of economic activity. Further, we find this effect accompanied by a shift in regional employment shares. In regions with connected towns, manufacturing employment shares increase by 1.3 percentage points relative to regions getting connected later. This is consistent with the literature on industry-bias of ICT toward high value added sectors (see, e.g., Baumol, 1967; Ngai and Pissarides, 2007). Heterogeneity analyses with respect to different measures of market access suggest stronger effects in towns better integrated into regional markets, in line with existing works that establish complementarity between ICT and trade (see, e.g., Baldwin, 2019; Steinwender, 2018).

To ensure that our results are indeed driven by internet availability, in addition to town and country-year fixed effects we control for the rollout of mobile GSM coverage.[3] Our model further takes into account potential changes in the importance of geographic factors over time. Apart from absent pre-trends, placebo tests corroborate that the effect is tied to the unique structure of the exogenous variation we exploit. It is therefore unlikely that treatment is confounded by parallel infrastructure rollouts. Nevertheless, we assess this possibility more directly using georeferenced survey data on electricity availability and find no evidence in support of parallel expansion of electricity grids. We assess robustness of our results to alternative model specifications, in particular regarding the composition of the control group and measurement approaches. Finally, we estimate less demanding variations of our model to assess robustness on larger sample sizes and external validity.

This study makes three main contributions. First, our unique settings allows us study the causal effect of internet availability on local economic growth in a sample of remote towns in rural SSA. We are the first to show and quantify significant effects for rural SSA during the period when internet first became available in these areas, which feature labor-intensive, agrarian economies. We show that internet availability has an effect on economic growth beyond political and economic centers and thus contributes to rural development in developing countries. Second, while most studies are concerned with broadband internet, we focus on low-speed connectivity. As alternative means to access the internet in SSA were non-existent or prohibitively expensive, especially in rural areas, our shock truly measures the extensive margin of internet, from virtually no connectivity to speeds between 0.5 and 2 Mbps enabling basic functionality like e-mail and web browsing. Third, people in rural SSA predominantly access the internet via cybercafés during the 2000s before mobile internet spread to rural areas from 2010 onward. We contribute by examining growth effects of the internet in the context of these community-based and cost-efficient institutions, which are overlooked in the literature with its heavy focus on mobile internet.

The remainder of this paper is organized as follows. First, we discuss related literature in Section 2. Section 3 introduces the data. In Section 4, we present our empirical strategy. Results are provided in Section 5 and Section 6 concludes with a discussion.

[3]During our observation period, all countries only had basic (GSM) mobile coverage which enables calls and SMS messaging, but not surfing the web. Importantly, 3G coverage, and therefore mobile internet, was unavailable.

2 Related literature

Internet and economic growth We contribute to three main strands of literature. First, we add to the broad literature assessing the impact of the internet on economic growth. For developed countries, the effect of digital infrastructure and especially (broadband) internet has been assessed widely. For example, Czernich et al. (2011) identify an effect of broadband infrastructure on annual per-capita growth in OECD countries. Bertschek and Niebel (2016) find a firm-level productivity effect of mobile internet in Germany. For the US, Kolko (2012) finds a positive relationship between broadband expansion and a host of local economic outcomes such as population growth, employment, and wages. For developing countries, (Hjort and Tian, 2021) survey the evolving literature on internet and growth. Much of this literature is focused on mobile internet, as mobile phones are the main technology through which individuals access the internet in developing countries at least since 2010 (see, e.g., Rodríguez-Castelán et al., 2021; Williams et al., 2011; Aker and Mbiti, 2010). Several recent studies examined the effect of mobile internet availability in developing countries in the 2010s and quite consistently found an increase in consumption and a reduction in poverty, e.g., in Nigeria (Bahia et al., 2020), Senegal (Masaki et al., 2020), and Tanzania (Bahia et al., 2021). Focusing on mobile internet *use*, Roessler et al. (2021) show smartphone use increased per-capita household consumption significantly. In contrast, Suri and Bhattacharya (2022) find no impact on a wide range of economic outcomes including employment and consumption in a RCT distributing free phone data in Kenya. Haftu (2019) observe an effect of mobile phones but not for internet availability on per-capita income at the country level. Similarly, Rotondi et al. (2020) find an effect of mobile phone coverage and ownership on rural development in developing countries. At the country level, Thompson and Garbacz (2011) finds stronger effects of mobile internet in low-income countries, but no effects of fixed-line broadband. Evidence on the channels through which economic outcomes in developing countries are affected by the internet remains scant. Generally, the broader literature suggests internet advances economic growth by reducing information frictions, improving the management of supplies, increasing the productive efficiency of firms, and reducing transportation costs (see, e.g., Aker, 2010; Hjort and Tian, 2021). In Brazil, Barbosa et al. (2021) find organizational firm restructuring and employment losses in response to broadband availability. Hjort and Poulsen (2019) study the employment effects of large increases of available international bandwidth around 2010 in SSA and find a skill-biased and net positive employment effect at the individual level.

Our study is the first to causally investigate growth effects of early, low-speed connectivity when the internet first became available in rural SSA. This contrasts with the literature's focus on mobile internet after 2010, which leads to the previously prevalent institution of cybercafés being largely overlooked. Cybercafés are important institutions that introduced the internet to most individuals in SSA during the 2000s (Southwood, 2022). As cybercafés do not require individual-level hardware, they are extremely cost-efficient and serve entire local communities with minimal infrastructure. It is important to understand such community-based modes of technology access as well as their economic effects in more detail. Especially in remote areas or where legacy infrastructure is lacking, their scalability and cost-efficiency is a crucial feature to achieve widespread adoption quickly. This work emphasizes that internet infrastructure availability in a setting where cybercafés are the predominant access technology enhances local economic growth in remote areas of developing countries.

ICT and market integration A growing literature investigates the effects of information and communication technologies on market integration. ICT facilitates the integration of markets by improving communication and information flows. Reserach shows that, by reducing information frictions, ICT enhances, e.g., the efficiency of labor markets (Autor et al., 2015) and fosters trade (Leuven et al., 2021; Steinwender, 2018; Freund and Weinhold, 2004). Generally, ICT is found to exhibit a skill- and sector-bias and therefore affects industries and occupations differently (see, e.g., Michaels et al., 2014; Ngai and Pissarides, 2007; Autor et al., 2006; Baumol, 1967) and likely also has differential effects on trade (Grossman and Rossi-Hansberg, 2008). For developing countries, the literature on the role of ICT for market efficiency is still slim. Baldwin and Forslid (2023) argue digital technologies enable developing countries to pursue a services-led growth model by exploiting comparative advantages in previously untradable sectors. In their seminal paper, Jensen (2007) shows how price dispersion drops in response to mobile phone adoption in rural India around 2000. Aker (2010) confirms this effect of the introduction of mobile phones on prices between 2001 and 2006 in Niger. For Chinese firms, Fernandes et al. (2019) observe increased exporting in response to internet availability.

This paper shows even remote towns in rural SSA benefit from internet availability. We add to this literature not only with our focus on remote areas in developing countries but also by explicitly analyzing low-speed, community-based internet connectivity. With the notable exception of Jensen (2007), the literature neglects the important era when ICT technologies became first available in the developing world. In line with existing literature studying developed economies, our analyses suggest a complementary between (regional) trade and ICT even in a setting with agrarian and labor-intensive economies and low literacy rates.

Regional development, geography, and infrastructure There is a large body of related literature on the effect of infrastructure provision on regional development. Infrastructure provision is typically much less profitable and at the same time more expensive in rural areas (see, e.g., Chaurey and Le, 2022). There is an established literature for developing countries for non-digital infrastructure, most importantly transportation (see e.g., Asher and Novosad, 2020; Banerjee et al., 2020; Aggarwal, 2018; Donaldson, 2018; Jedwab et al., 2017; Ghani et al., 2016; Storeygard, 2016; Faber, 2014) and electricity (see e.g., Lee et al., 2020; Burlig and Preonas, 2016; Chakravorty et al., 2014; Grogan and Sadanand, 2013; Rud, 2012; Dinkelman, 2011). Although not in all settings, this literature largely finds infrastructure beneficial for regional development. For digital infrastructure, the literature on regional development predominantly considers developed countries (see, e.g., Briglauer et al., 2019). Although the regional digital divide is discussed widely (see, e.g., Lagakos, 2020; Fukui et al., 2019; Buys et al., 2009), only few studies investigate settlements outside of the large cities in more rural and remote areas (e.g., Hjort and Poulsen, 2019). Rotondi et al. (2020) acknowledge the potential of mobile phones for rural development in poor countries. A more active strand of literature assesses regional inequality in developing countries as with rapid urbanization (OECD, 2020) rural areas fall behind economically. Economic productivity is typically higher in urban areas for several reasons including thick labor markets, knowledge spillovers, and low transportation costs (see, e.g., Curiel et al., 2017; Albouy, 2016; Clark et al., 2002; Deller et al., 2008). While studies mostly compare the economic progress in mega-cities versus secondary cities, with inconclusive findings regarding inequality trends (e.g., Bluhm and Krause, 2022; Christiaensen and Kanbur, 2017; Fetzer et al., 2016; Christiaensen and Todo, 2014), studies on rural agglomerations are lacking. Notably, Henderson et al. (2012) indicates that the hinterland grows faster than coastal areas and primate cities do not grow faster than their hinterland.

Our work contributes by showing that connectivity effectively contributes to narrowing the digital divide in remote towns in rural areas of developing countries. Although we cannot speak to the relative development with respect to secondary and primate cities, we observe unconnected remote towns falling further behind compared to their incidentally connected counterparts. We further corroborate findings in existing works of positive effects of ICT infrastructure in rural SSA and show that individual-level effects sum up to significant aggregate effects on economic growth at the local level of towns.

3 Data

To assess the impact of internet availability on local economic growth, we combine data on economic growth and internet infrastructure at the level of towns in Sub-Saharan African (SSA) countries.[4]

3.1 Local economic growth

For SSA countries, comprehensive sub-national or even city-level records of economic activity is lacking, especially panel data is unavailable. Therefore, we use night-time light (NTL) emissions as a proxy for economic activity. NTL data is available worldwide from 1992 until 2013 from the U.S. Air Force *Defense Meteorological Satellite Program*'s *Operational Linescan System* (*DMSP-OLS*). The instruments of *DMSP-OLS* satellites measure light intensity on an integer scale from 0 to 63 with pixels covering 30 arc-second grid cells, an area of .86 square kilometers at the equator. In most years, at least two satellites are deployed to capture NTL; *DMSP-OLS* data averages measurements and reports yearly composites. The remote sensing community acknowledges the usefulness of NTL data to measure economic activity (see, e.g., Levin et al., 2020; Levin and Duke, 2012), but emphasizes the importance to correct *DMSP-OLS* composites for various sources of measurement error such as saturation (Ma et al., 2014) and atmospheric light (Wei et al., 2014). Recently, shortcomings of the raw data like the lack of calibration are increasingly recognized in economics

[4]We define Sub-Saharan Africa as the mainland of the African continent without the Northern African countries, Algeria, Egypt, Libya, Morocco, Tunisia, and Western Sahara. We exclude South Africa as economically more developed country due to lack of comparability.

(Gibson et al., 2021). We use the harmonized version of the yearly *DMPS-OLS* composites from Li et al. (2020), who extract only light emitted by human settlements by excluding night lights from aurora, fires, gas flares, boats, and other temporal lights unrelated to human settlements and make the data temporally consistent via an exhaustive inter-calibration procedure.

NTL data is an established proxy for local economic growth (see, e.g., Asher et al., 2021; Bluhm and McCord, 2022), especially where official statistics are lacking or unreliable (Donaldson and Storeygard, 2016; Nordhaus and Chen, 2015; Chen and Nordhaus, 2011). In general, NTL emission by human settlements represents mostly outdoor use of light typically associated with human consumption or production activities, which is, in turn, closely related to income and GDP (Levin et al., 2020). However, this relationship is complex, indirect, and noisy; and by using it we abstract from many issues such as public versus private light emissions, tracing specific sources of light, or classifying light emission of settlements into consumption versus investment activities. Yet, there is an empirically well-established relationship between NTL and economic growth. In the economic literature, Henderson et al. (2012) demonstrate the (linear) relationship between GDP growth and NTL growth at the country level and Storeygard (2016) as well as Chen and Nordhaus (2011) validate that this also holds at the sub-national, grid, or city level. Bluhm and McCord (2022) find NTL data more suited to capture changes in GDP at lower baseline levels of GDP and population densities, and Mellander et al. (2015) shows NTLs tend to slightly overestimate economic growth in large urban areas and underestimate growth in rural areas. Other concerns regarding NTL data like blurring and top-coding are concentrated in cities and metropolitan areas (see, e.g., Gibson et al., 2021; Bluhm and Krause, 2022). NTL data therefore is especially well-suited for our analysis, targeting mid-sized towns in remote areas of SSA.

The key advantage of NTL data is its geographic specificity. To measure local economic growth at the town level, we map NTL data to human settlements using built-up areas from *Africapolis* (OECD, 2020).[5] This database contains the geographical delineation of 7,496 SSA towns and cities with more than 10,000 inhabitants in 2015. By integrating small towns into the data and combining satellite imagery with various census and administrative sources, *Africapolis* data is the first to provide comprehensive geographic information on the agglomeration landscape in SSA. The median size of an *Africapolis* agglomeration in 2015 is about 21,000 inhabitants and around 90% of towns feature less than 100,000 inhabitants. In 2000, agglomerations were considerably smaller with a median population of about 10,000, and about 90% of agglomerations inhabited by less than 45,000 people.

3.2 Internet infrastructure

We measure internet availability across time at the town level by combining two data sources. Our first source is *Africa Bandwidth Maps*, a database maintained by *Hamilton Research* and sourced directly from

[5] https://africapolis.org, accessed on 01/05/2023.

network operators.[6] The database contains a comprehensive record of internet access points and their locations on the African continent and covers the period from 2009 until today, updated yearly. The data represents a detailed record of national fiber-optic internet infrastructure rollout in SSA. Before construction of such cables, internet access in SSA was extremely limited and prohibitively expensive (see, e.g., LeBlanc and Shrum, 2017; Williams, 2010; Gitta and Ikoja-Odongo, 2003).[7] Consequently, national internet backbone access constituted the first viable and affordable way to go online for the vast majority of SSA people, especially in rural areas (see, e.g., Kitimbo, 2023; LeBlanc and Shrum, 2017).

An internet access point is a node in the (usually fiber-optic) backbone of a nation's internet network. From the access points, internet users in the surrounding area are reached by local 'last mile' infrastructure. At the time, users in rural Sub-Saharan Africa predominantly accessed the internet via cybercafés (see, e.g., Williams et al., 2012; Southwood, 2022). Cybercafés (or: internet cafés) are community-based centers with wired internet access typically in the form of small shops or rooms with computers (LeBlanc and Shrum, 2017). In the 2000s, cybercafés usually were the only way to access the internet in rural SSA (Williams et al., 2012), and people not only used cybercafés for communication and entertainment but also for professional purposes such as maintaining business contacts and managing the delivery of goods and supplies (see, e.g. Gitta and Ikoja-Odongo, 2003; Mbarika et al., 2004). We provide further background on last-mile transmission technologies and cybercafés in Sub-Saharan Africa in the 2000s in subsection A.2 in the Appendix.

We leverage the *Africa Bandwidth Maps* data on access points to measure local internet infrastructure availability. Using the geolocation information, we compute the geographic distance between each *Africapolis* town and the nearest access point to define towns as within-reach when being located within a distance of 10 kilometers to an access point.[8] Note that this measure of internet infrastructure availability does not ensure local adoption at the town level as we do not directly observe the presence of cybercafés nor other means of local end-user uptake. Therefore, similar to other studies exploiting local internet infrastructure availability, our results are best interpreted as intention-to-treat effect (ITT). The ITT effect is typically of particular interest when estimating aggregate effects as it takes into account adoption rates. In addition, ITT effects in this institutional setting might be particularly strong. The predominant access mode through cybercafés at the time did not require individual hardware adoption and nearby presence of a cybercafé is highly likely in locations with internet availability (Williams et al., 2012). Therefore, cybercafés have the potential to serve entire local communities with internet access efficiently (Southwood, 2022).

We infer the construction date of access points from the first year they show up in the data. For access points already present in the first data year, 2009, we conduct an extensive review of internet backbone deployment

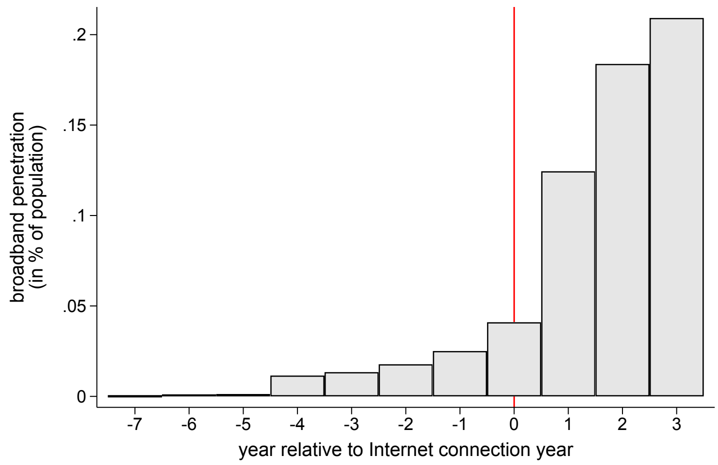
[6] `http://www.africabandwidthmaps.com`, accessed on 04/11/2023.

[7] Technologies used prior to national backbone access were either satellite- (e.g., VSAT) or telephony-based via narrowband dial-up modems (Williams, 2010; Nyezi, 2012).

[8] According to the literature (see, e.g. Ngari and Petrack, 2019) as well as interviews with industry experts, this is an appropriate (average) distance. Robustness checks with alternative distance cut-offs supports this information (Table B.20 and Table B.19).

projects for each SSA country to determine their construction date, going back until the late 1990s. Although it is not always possible to determine the exact year of construction, we are able to determine which access points were constructed until the year the countrywide internet connection was established, which is sufficient information for our analysis.[9] Figure C.9 maps of all 2,708 access points and their construction year.[10] We provide a brief overview of each countries' national backbone expansion in Table B.2, and subsection A.1 details a country example as well as further background information on national backbone rollouts in SSA.

Figure 1: SMC connection and internet adoption



Note: International capacity is calculated from SMC capacities assigned to each country by using population-weighted shares. Adoption rates are calculated relative to the establishing year of the Internet connection in each country and then aggregated taking the weighted mean. Weights are population size in 2000.

Our second data source is the *Submarine Cable Map* by *TeleGeography*, a comprehensive collection of information on global submarine cables.[11] Submarine cables are fiber-optic cables for large-scale international data transmission over long distances and form the backbone of the international internet infrastructure. SMC construction typically is a joint effort of governments, private investors, and/or multinational organizations (Williams, 2010). The arrival of the first wave of internet-enabled SMCs in SSA countries from 1999 until the mid-2000s first brought internet connection to Sub-Saharan Africa at noticeable scale. The largest SMC from the initial wave is SAT-3 which started operating in 2001 and featured landing points in nine West

[9]Documentation of our review of deployment projects, including a source register, is provided in Table D.23 in Appendix D.

[10]About half of them were constructed after 2013 and larger cities are typically served by more than one access point, usually for bandwidth reasons. This implies that, for example, in 2019, although 189 new access points were constructed, only 27 cities and towns were first connected. In total, around 900 *Africapolis* cities and towns are within-reach of an access point in the most recent year of our data (2020).

[11]*Submarine Cable Map:* https://www.submarinecablemap.com, accessed on 04/11/2023.

African countries.[12] Before SMC arrival, the number of SSA internet users was tiny, with only 0.2 million users in 1998, while in 2002 already 3.2 million people used the internet (Southwood, 2022). With the first wave of SMCs, international bandwidth constraints that previously kept prices high relaxed considerably. Figure 1 shows that internet adoption rates jump in SSA countries after SMC arrival, although still remaining at relatively low levels.[13] SMCs of the first wave provided capacities for internet at basic speeds, i.e., connections featuring around 0.5 to 2 Mbps (Hjort and Poulsen, 2019; Agyeman, 2007). Between 2009 and 2012, these SMCs were proceeded by the next generation of SMCs with much higher capacities enabling higher-speed internet connectivity.[14] Landings of SMCs are often described as transformative moments for SSA countries (see, e.g., Graham et al., 2015).

For our empirical analysis, we use the date on which first-wave submarine cables connecting SSA counties start operating, the so-called *ready-for-service* (RFS) date as well as information on the exact landing point in each SSA country from the *Submarine Cable Map*. The RFS year of the first SMC in a country marks the year in which international internet connection was established. Connection to the international internet network is crucial for SSA countries since, especially at the time under study, the vast majority of web pages and applications used in SSA are hosted on servers located in North America or Europe, and thus almost all African internet traffic is routed inter-continentally (Kende and Rose, 2015; Chavula et al., 2015).[15] We geolocate the landing points and relate each of them to an *Africapolis* agglomeration. For countries that established international internet connection through a neighboring country (mostly landlocked countries), the date at which a border access point was established marks the connection year.

We exploit RFS dates as differences in the timing of SMC arrival introduce quasi-random and country-wide variation in internet availability. Hjort and Poulsen (2019) introduced this shock in the economic literature. Three features of this setting come together that are important for the identification strategy in this paper. First, the need of SSA internet traffic to be routed intercontinentally. Second, the fact that each SSA country has a single national backbone network with roughly equal (technically feasible) speed irrespective of the distance to the SMC landing point. This implies that each SSA country has a specific and country-wide treatment date – the year of SMC arrival. Third, the order in which SSA countries are reached by SMCs is geographically determined. This generates quasi-random variation in the timing of internet availability across SSA countries.

[12]SSA countries connected by SAT-3 are Angola, Benin, Cameroon, Côte d'Ivoire, Gabon, Ghana, Nigeria, Senegal, and South Africa. The cable originates in Sesimbra, Portugal, and Chipiona, Spain, and routes via the Canary Islands in Alta Vista.

[13]See Table B.1 for country-specific connection years. Before the first SMCs landed on SSA shores, the only way to connect to the internet on the continent was via satellite or telephony cables. Telephony cables are unavailable in the vast majority of SSA, especially in rural areas. While being largely unconstrained by geography and local infrastructure, satellite connection is costly and allows only for narrow bandwidths. South Africa, which we do not study here, was connected in 1993 through an internet-enabled SMC (SAT-2) that preceded an old co-axial telephone cable from 1968 (SAT-1).

[14]Country-specific years of this 'speed upgrade' are reported in Table B.1.

[15]This is true even for 'local' content like websites of SSA businesses and organizations as hosting infrastructure such as data centers within SSA is lacking, especially at the time we study.

3.3 Supplementary data

To take into account simultaneous expansion of other digital infrastructure, we draw on mobile coverage data from *Collins Bartholomew*. Their *Mobile Coverage Maps* provide information on the availability of mobile signal and differentiate between the cellular technologies GSM (2G), UMTS (3G), and LTE (4G). During our observation period, GSM (2G) mobile signal became available in SSA countries and none of the countries in our sample started rolling out internet-enabled UMTS technology. From the yearly shape files provided in the data, we compute, for each town in our sample, the share of its built-up and 2 kilometer buffer area covered with GSM signal in each year. Typically, this town areas are either fully covered or no signal is available, i.e., the resulting value is either 0 or 1. While not enabling mobile internet, GSM signal implies the availability of basic communication functionalities such as making calls or sending short text messages.

We further tap time-varying geographic data on local population density from *Gridded Population of the World* (*GPW*) provided by the *NASA Socioeconomic Data and Applications Center* (*SEDAC*). *GPW* data models the distribution of human population counts and densities on a continuous global raster surface. This data offers the same spacial resolution as the *DMPS-OLS* NTL data (30 arc-second grid cells), but comes only in a time resolution of five-year intervals. We proxy town-level population similarly to economic activity by aggregating pixels within buffered built-up areas and applying the natural logarithm.

Data on employment by industry originates from census data in the *IPUMS International* database.[16] We aggregate this household-level data to the sub-national regional level (Admin-2) and caluclate employment shares by industry, i.e., agriculture, manufacturing, and services. Censuses are carried out roughly every ten years and at different points in time for different countries. For details on census years by SSA country, see Table B.8 in the Appendix.

We obtain additional geographic information from various sources. From *OpenStreetMap* (OSM), we source information on the status as national or regional capital and link it to *Africapolis* towns.[17] To assign the status as economic center to a town, we use population information in the year 2000 from *Africapolis*. Furthermore, we use OSM to collect the location of financial, health, and educational infrastructure, as well as rivers. We obtain information on other transportation infrastructure from *Natural Earth Data* (roads and railroads) and the *World Port Index* (shipping ports).[18] *Africapolis* provides information on each town's altitude and population density. In addition, we source data on terrain ruggedness in 30 arc-second resolution from Nunn and Puga (2012).[19]

[16] *IPUMS International:* https://international.ipums.org/international/, accessed on 04/12/2023.

[17] *OpenStreetMap*: https://www.openstreetmap.org/.

[18] *Natural Earth Data*: https://www.naturalearthdata.com/, accessed on 04/12/2023; *World Port Index*: https://msi.nga.mil/Publications/WPI, accessed on 04/12/2023.

[19] Nunn and Puga (2012) data: https://diegopuga.org/data/rugged, accessed on 04/12/2023.

3.4 Combining the data

We are interested in the development of remote towns in SSA countries in response to an exogenous shock in internet availability. To this end, we track NTL emissions of each town over time by assigning *DMSP-OLS* NTL pixels to *Africapolis* towns and measure internet availability in each of these towns via access points from *Africa Bandwidth Maps* and SMC arrival dates from the *Submarine Cable Map*. As we focus on incidentally connected remote towns, 'nodal cities' – national and regional capitals as well as economic centers – are excluded. Specifically, we define economic centers as cities with more than 50,000 inhabitants in 2015 according to *Africapolis*.[20]

Our subjects of interest are remote towns in Sub-Saharan Africa. During our observation period, by far not all remote towns receive internet access points. We thus define our comparison group using two criteria. First, we select remote towns, i.e., non-nodal cities, for which an internet access point becomes available until the end of our data period in 2020. Second, we include only towns that remain unconnected until the end of our five-year post period, so that there are no compositional changes in treatment and control group during the observation period, which would confound our analysis. As a result, there is a trade-off between the length of our observation period and comparability of treated and control towns. To make sure our specification is appropriate, we show parallel trends and robustness to changes in the specification with respect to observation period definition (see subsection 5.2).

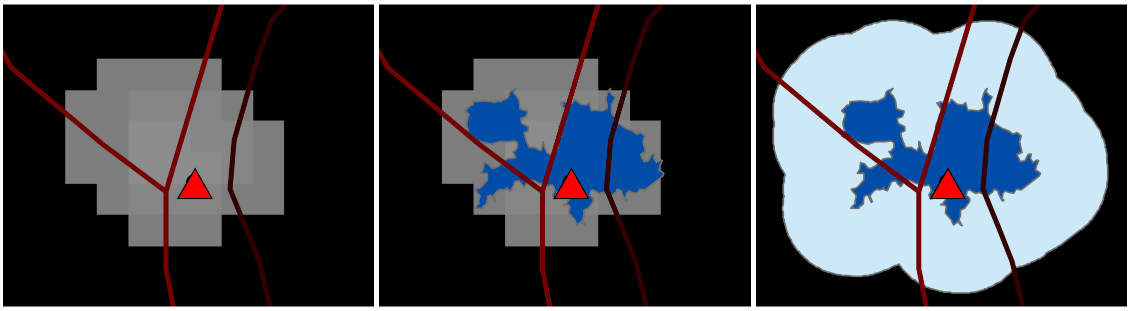
NTLs are the best available measure to track economic growth of remote towns in SSA countries for two main reasons. First, NTLs provide the necessary geographic resolution to measure local economic growth of each town. Second, remote towns lie far enough away from each other to clearly separate lights emitted by nearby towns. Panel (a) of Figure 2 shows Dassa-Zoumè in Benin in 2004, a typical town for our sample with around 19,000 inhabitants in 2000, according to *Africapolis* estimates. The contiguous area of gray pixels represent NTL emissions of Dassa-Zoumè and can clearly be attributed to the town, with lighter gray pixels indicating stronger light emissions. Roads leading through Dassa-Zoumè are depicted as red lines and railroads in dark red.

We require a town to emit NTL in each year of observation avoid measurement error due to background noise in the data (Chen and Nordhaus, 2011). This ensures that the data captured represents an appropriate proxy for economic growth at the town level, but comes at the expense of losing the smallest towns. With this measurement method, we are able to trace the economic growth of *Africapolis* towns with on average around 16,000 inhabitants in 2000 and a distribution ranging from 10,000 to 50,000 excluding nodal cities. Figure C.13 displays the density distribution for towns in our sample. An additional advantage of the stable light emission requirement is that included towns likely have electricity connection over the whole observation period (Falchetta et al., 2020; Dugoua et al., 2018), precluding electricity grid expansion as

[20] Robustness tests with respect to this choice are presented in Table B.16 and Table B.17.

a confounding factor in our analysis. Nevertheless, we perform robustness analyses with respect to this requirement in Table B.11 and Table B.12.

Figure 2: Data example Dassa-Zoumè, Benin (2004)



(a) **(b)** **(c)**

Note: Panels (a) through (c) show a data example for Dassa-Zoumè, Benin, in 2004. Panel (a) shows NTL emissions for the year 2004, three years after the SMC connection year of Benin. Light intensity is shown by lighter grays. The red triangle indicates an internet access point is present in 2004 (built in 2001, in this case). Red linkes represent major roads and dark red lines railways. Panel (b) additionally shows Dassa-Zoumè's built-up area in dark blue. Panel (c) adds a 2 kilometer buffer around the built-up area in light blue. Sources: Li et al. (2020), *Africapolis*, *OpenStreetMap*, *Natural Earth Data*, *Africa Bandwidth Map*.

DMSP-OLS NTL emitted by human settlements blurs out to adjacent pixels, so NTL extend beyond towns actual geographic expansion, measured by their respective *Africapolis* built-up areas. Panel (b) of Figure 2 shows this for the town Dassa-Zoumè in Benin in 2004. The NTLs (gray) extend out of the towns' built-up area (blue). This phenomenon is known as 'blurring' or 'overglow' (Abrahams et al., 2018). We account for NTL blurring by extending the built-up area by a buffer area of 2 kilometers in order to capture all NTLs emitted by a town. As illustrated for Dassa-Zoumè by Panel (c) of Figure 2, this allows us to include all relevant NTL pixels.[21]

For each town-year, we measure NTL emissions by summing up the light intensities of pixels within a town's area as defined above. This method of local NTL aggregation was proposed and validated by Storeygard (2016) and accounts for both increased light intensity and geographical expansion. Changes in NTL emissions over time are a measure of economic growth as shown in Henderson et al. (2012) and Storeygard (2016). Specifically, Henderson et al. (2012) observe a stable linear relationship between changes in NTL and GDP growth both in a worldwide sample of countries and for low- and middle-income countries in particular, with an estimated light-to-GDP elasticity of around 0.28. This implies that a 10% increase in NTL from one year to the next translates to a 2.8% increase in GDP year-on-year.

In addition to this composite NTL measure, we derive two other measures from NTL. First, we compute the average light intensity of all pixels in a town's area as an indication for per-capita GDP growth (intensive margin). Second, we calculate the sum of all lit pixels in a town's area as a measure of population growth

[21] For robustness, we also show the results for a specification without a buffer as well.

through spatial expansion (extensive margin). Although noisy and imperfect, these measures provide suggestive evidence on the underlying source of economic growth. As an alternative to the NTL-based measure of intensive-margin growth, we separately analyze changes in population via high-resolution grids from the *GPW* database.

Lastly, for each town in each year we compute if there is an internet access point within-reach, i.e., within 10 kilometer distance. According to available information (see, e.g., Ngari and Petrack, 2019) and interviews with telecoms experts, this is an appropriate average reach of technologies at access points used at the time. If a town is located less than 10 kilometers away from an access point, we record a town as connected to the national backbone. In Dassa-Zoumè, for example, there is an access point within-reach in 2004 (built in 2001), marked by red triangles in Figure 2. Together with the information of the date when a SMC first arrives in the respective country in which a town is located, we know when internet first became available in each town.

3.5 Descriptive statistics

Our analysis is focused on mid-sized, remote towns. With our measurement technique, we identify 510 agglomerations in 10 SSA countries emitting NTLs each year. Thereof, 70 agglomerations (13.7%) are classified as nodal cities and 118 towns (23.1%) are still unconnected to an internet access point at the end of our data period in 2020. 112 towns (21.9%) received access to the national backbone during the five-year post-period after SMC arrival and are excluded in our main specification as their treatment confounds the control group. Thus, our main sample contains 210 towns in 10 SSA countries, where there are both treated and control towns, with yearly NTL emission in the observation period and eventually receiving access to the national backbone in their country. This represents 41% of agglomerations detected via NTL and 18.9% of all *Africapolis* towns in the studied countries.[22] In our sample, 97 towns (46.2%) were already connected to the national backbone via an access point prior to country connection via SMC or a neighboring country and therefore form the treatment group. The remaining 113 towns constitute the control group and receive access to the national backbone, too, but after the five-year post period. Table B.3 reports summary statistics for our sample.

Our identification builds on a comparison of remote towns receiving connection prior to SMC arrival due to their location on-route between nodal cities, and remote towns connected to the national backbone only later. On average, treated towns have 16,595 and control towns 16,314 inhabitants. Treated and control group towns are not only almost identical in their average population but also in their population distribution (Figure C.13). In addition, we show our comparison captures similar towns by analyzing the expansion of national backbones that connects more cities and towns over time. Panel (a) of Figure C.2 plots the average population size in each year relative to the country connection year for towns in our sample as well as nodal

[22] The *Africapolis* data records a total of 1,113 agglomerations with less than 50,000 inhabitants in 2000 in countries with both treated and control towns.

cities. Nodal cities connected earlier are much larger and average population size declines quickly at first and more slowly after about five years post-connection. This shows that national backbone expansions prioritize larger nodal cities. Panel (b) of Figure C.2 focuses on treated and control towns and shows that there is no clear association of population size and connection timing for control towns. Average population size of control towns lies between 11,000 and 19,000, with no clear time trend relative to the country connection years. This points to the absence of selection into treatment and supports the notion of incidental connection of on-route towns.

4 Empirical strategy

Internet availability is not randomly assigned to locations. Our identification strategy aims to break the correlation between internet availability and unobserved determinants of local economic growth by exploiting two sources of exogenous variation: the staggered rollout of, first, the national internet infrastructure and, second, international sub-marine internet cables. This generates quasi-random spatial and temporal variation in internet availability conditional on town and country-year fixed effects as well as geography controls.

Our baseline fixed-effects panel data regression model to estimate the relationship between internet availability and local economic growth is a difference-in-differences specification:

$$\begin{aligned} y_{ic(i)t} = \beta_0 + \beta_1 \left(\text{connection}_{c(i)t} \times \text{access}_i\right) + \beta_2 \text{GSM}_{it} + \beta_{\mathbf{3}} (\mathbf{X}_i' \times \text{connection}_{c(i)t}) \\ + \alpha_{ic(i)} + \alpha_{c(i)t} + \varepsilon_{ic(i)t}, \end{aligned} \tag{1}$$

where $y_{c(i)t}$ is economic growth of town i in country $c(i)$ in calendar year t as proxied by nighttime light (NTL) intensity. Internet is available in town i in calendar year t if two conditions hold simultaneously: the country has a sub-marine cable connection and the town has access to the national backbone. The variable $\text{connection}_{c(i)t}$ indicates if *country* $c(i)$ has internet connection in calendar year t via a sub-marine cable, and access_i is an indicator if *town* i has internet connection, defined as being located within 10 kilometers (geodesic) distance to an access point at the time of SMC arrival in country $c(i)$. Consequently, the interaction term $\text{connection}_{c(i)t} \times \text{access}_i$ indicates internet availability in town i in country $c(i)$ in calendar year t.[23] The coefficient of interest is β_1 and captures the effect of internet availability on local economic growth.

This specification mimics a hypothetical situation where internet availability is randomly assigned to towns. The model essentially compares 'treated' towns that are connected to the national backbone at the time of SMC arrival to other ('control') towns that receive connection to the national backbone at a later point in time. We argue that this exploits two types of exogenous variation. First, we use exogenous variation in internet availability at the country level from the quasi-randomness in the timing of SMC arrival. SMCs arriving in SSA countries at the time under study come from Europe and typically feature one landing point

[23] To not confound our control group, we do not consider towns getting an access point in the post period as control towns in our main specification.

in each SSA country they passed. Thus, SMC arrival time is mainly geographically determined (Hjort and Poulsen, 2019). Together with separate national backbones in each country, this generates temporal variation in country-wide internet availability: at the ready-for-service date, internet becomes available in all locations within a country that are connected to the terrestrial backbone network.

The second source of exogenous variation in internet availability comes from the rollout of national backbones, during which remote towns typically receive an access point only when they lie on the route between nodal cities. The routes between nodal cities are built at different speeds due to geographic, political, or other reasons related to the nodal cities. Importantly, backbone expansion planning typically does not consider on-route towns due to their insignificant population size compared to nodal cities (see, e.g., Williams et al., 2011). As a consequence, some remote towns exogenously benefit from their location on the route between nodal cities that are connected before SMC arrival. Note that the comparison group are other remote towns that often lie on route between nodal cities, too, but are connected later. Thus, the staggered nature of national backbone rollouts creates spatial variation in internet availability at the time of SMC arrival for remote towns in SSA. We discuss a typical country example in detail in subsection A.1.

To factor out further confounding factors, we include two types of fixed effects as well as additional controls. Time-constant differences across towns are captured by town fixed effects $\alpha_{c(i)}$. Differences across calendar years common to all towns within a country are absorbed by country-year fixed effects $\alpha_{c(i)t}$. Note that this allows for country-specific time trends such as differential growth rates and also captures variation in satellite sensor quality over years. In addition, we account for mobile internet network expansion by using spatial coverage of each town with GSM signal, GSM_{it}. Lastly, we include a set of geography controls $\mathbf{X}_i$ interacted with the connection indicator $\text{connection}_{c(i)t}$ to allow for time-variation in the effect of geographic factors related to town-level growth. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. We use robust standard errors clustered at the level of access points to account for serial correlation in the error term $\varepsilon_{ic(i)t}$.

The key identifying assumption for β_1 is that treated towns would have evolved similarly to control towns in absence of treatment, i.e., if internet had not become available. The same underlying trends assumption cannot be tested. Its plausibility can, however, be examined by investigating pre-treatment differences in time trends between the treatment and the control group. It is a necessary, although not sufficient, but testable condition for same underlying trends that there are no trend differences between treatment and control group before the treatment. To this end, we conduct an event study and analyze the dynamic impact of internet availability on local economic activity by running the regression

$$\begin{aligned} y_{ic(i)t} = \mu_0 + \sum_{j(c(i))=\underline{T}}^{\overline{T}} \left[\mu_{1j} \left(t_{j(c(i))} \times \text{access}_i \right) \right] + \mu_2 \text{GSM}_{it} + \mu_3 (\mathbf{X}_i' \times \text{connection}_{c(i)t}) \\ + \delta_{ic(i)} + \delta_{c(i)t} + e_{ic(i)t}, \end{aligned} \tag{2}$$

where $t_{j(c(i))}$ indicates the year relative to treatment year, i.e., the year when internet became available in country $c(i)$, starting in relative year $j(c(i)) = \underline{T}$ and ending with relative year $j(c(i)) = \overline{T}$. The treatment year is normalized to $j(c(i)) = 0$. We omit $j(c(i)) = -1$ as the reference point. The interaction $t_{j(c(i))} \times \text{access}_i$ indicates if town i in country $c(i)$ is part of the treatment group and restricts the coefficient to relative year $j(c(i))$. Thus, the coefficients μ_{1j} capture the dynamic effect – i.e., the effect for each relative year – of internet availability on local economic growth.

We further assume that there is no other time-varying within-country variation net of controls that correlates with the interaction of SMC arrival and backbone access and affects local economic growth independently of internet availability. There are three main threats to identification: measurement error, omitted variables, and model misspecification. We discuss all of these in Section 5.2.

5 Results

We use the difference-in-differences model in Equation 1 to estimate the average treatment effect on the treated (ATT) of Internet availability on local economic growth at the town level. The regression results are presented in Table 1. In line with our expectations, we find a positive relationship between Internet availability and local economic growth. Models (1) to (3) show a statistically highly significant effect of Internet availability on the standard light intensity composite measure – the logarithmic sum of light intensities of a towns' pixels. We translate these effects into GDP growth effects by using the elasticity between changes in night time light and GDP growth from Henderson et al. (2012) of $\varepsilon_{\text{GDP, light}} = 0.283$. The resulting GDP growth effects are reported in the last row of Table 1 and are economically significant in size. The effect from our preferred specification in model (3) corresponds to a 3.26 percentage point higher GDP growth in connected towns in the five years after SMC connection relative to control towns connected later.

The time-varying control for GSM mobile coverage is only weakly statistically significant but still economically sizable yet smaller than the main Internet effect. Its inclusion leads to more precise estimation of the main effect, which increases slightly. As mobile Internet is the main alternative form of Internet infrastructure in rural Sub-Saharan Africa at the time, this suggests that the Internet access points and complementary last-mile infrastructure are in fact driving the main effect and not by simultaneous expansion of mobile coverage in treated towns. We discuss the role of mobile coverage in more detail in subsection 5.2.

Increasing model flexibility by including geography controls interacted with an indicator for the post-connection period in model (3) improves model fit and reduces size and precision in the estimates of Internet access effects. This specification allows the effects of geographic factors such as distance to transport infrastructure or markets to vary over time. In fact, recent literature suggests market access and travel times have become less important over the last decades in developing countries (see, e.g., Henderson and Kriticos, 2018; Brülhart et al., 2020). There is also evidence that ICT contributes to decreasing importance of

Table 1: The effect of Internet availability on local economic growth

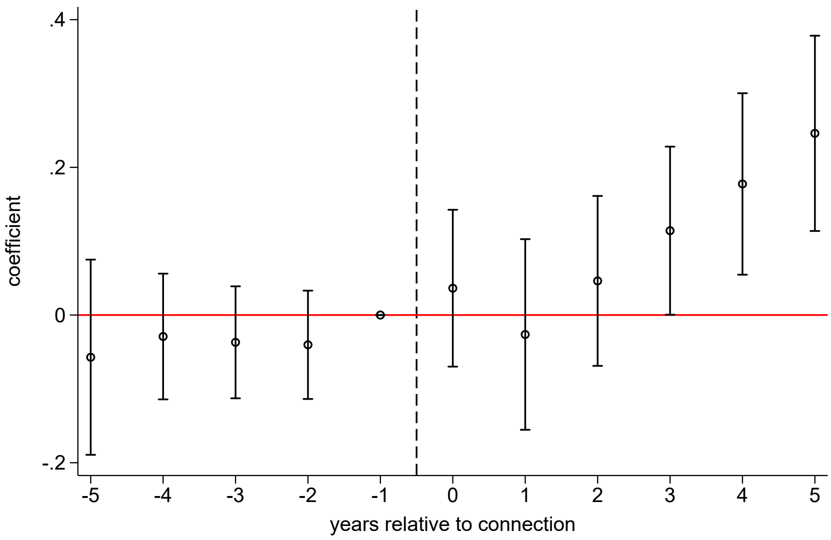
	NTL growth			NTL growth margin	
	(1) composite	(2) composite	(3) composite	(4) intensive	(5) extensive
Connection × access	0.129***	0.134***	0.109***	0.0769***	0.0817**
	(0.0427)	(0.0433)	(0.0383)	(0.0237)	(0.0330)
Town FE	×	×	×	×	×
Country × year FE	×	×	×	×	×
GSM coverage		×	×	×	×
Geography controls × connection			×	×	×
Observations	2,310	2,310	2,310	2,310	2,310
Countries	10	10	10	10	10
Towns	210	210	210	210	210
Share treated	*.462*	*.462*	*.462*	*.462*	*.462*
Adjusted R^2	0.936	0.936	0.948	0.923	0.919
Economic growth effect	3.90	4.06	3.26	—	—

Notes: NTL light intensity in Models (1) to (3) is measured as the logarithmic sum of light intensities. The corresponding economic growth effect in percentage points is calculated as $[[\exp(\hat{\beta}_{\text{connection}\times\text{access}}) - 1] * \varepsilon_{\text{light, growth}}] * 100$ using the elasticity $\varepsilon_{\text{light, growth}} = 0.283$ from Henderson et al. (2012). The intensive margin in Model (4) is measured by the logarithmic mean light intensity and for the extensive margin in Model (5) as logarithmic sum of lit, i.e., non-zero, pixels, all on the same area. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

geography as it improves communication with and thereby increases integration into larger markets (Steinwender, 2018). Model (3) shows that the main effect is not driven by changes in the economic benefits from geographical factors common to all towns.

To assess the plausibility of the same underlying trend assumption as well as the dynamics of the effect, we plot the estimated event study coefficients μ_{1j} from the regression in Equation 2 in Figure 3. We omit the year before SMC arrival as reference point. There are no differences in pre-trends between connected and unconnected towns before SMC arrival, depicted by insignificant estimates close to zero for all pre-treatment years. About two years after SMC arrival the trends diverge and connected towns start to grow substantially faster compared to unconnected towns, conditional on controls. From the third post-treatment year onwards these dynamic estimates are significant. We exploit a shock in Internet availability and therefore it is expected that there is a lag until an economic effect materializes as adoption or behavioral adjustments take time. Our dynamic results suggest a sustained growth advantage due to internet availability in connected towns up to five years post treatment, the end of our observation period, but do not speak to the persistence of the growth advantage beyond this period.

Figure 3: Dynamic effect of Internet availability on local economic growth



Note: The figure plots event study coefficients μ_{1j} based on Equation 2. The outcome is the logarithmic sum of light intensities. Bars represent 95% confidence intervals using robust standard errors clustered at the level of the closest access point. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

5.1 Mechanism

We investigate potential mechanisms behind the main effect in three ways. First, we decompose NTL into proxies for intensive- and extensive-margin growth. Second, we consider migration via changes in high-resolution population grids. And third, we explore effect heterogeneity with respect to market access, transport infrastructure, and sectoral employment.

Growth margin Our composite NTL measure includes nightlight emissions as a result of both geographic expansion due to more lit pixels ('extensive' growth margin) and increased light intensity of previously lit pixels ('intensive' growth margin). Both channels are suggestive of different sources of growth. An increasing number of lit pixels points more towards potentially increased population, especially as rural towns in SSA typically do not accommodate population by increased inhabitants per square kilometer but through geographic expansion (Sakketa, 2023). In contrast, increased light intensity suggests growing economic activity. We distinguish these channels by estimating separate models for the number of lit pixels and average light intensity in models (4) and (5) in Table 1. Results show both channels play a role, but the intensive growth margin plays a more important role in terms of statistical significance.

As the extensive margin measured via NTL data might be confounded by blurring intensive-margin pixels, we study the extensive margin more explicitly using high-resolution population grids. For each town, we compute population estimates from the *Gridded Population of the World* data available every five years and use its logarithmic values as outcome variable in our baseline specification. Table B.15 reports the results for different sample specifications. We find insignificant but mostly slightly positive point estimates, although the sign is not stable in all specifications. We interpret these results as pointing to a subordinate role of migration to connected towns, i.e. the extensive growth margin, consistent with the NTL-based finding of a more pronounced intensive growth effect.

Table 2: Internet availability and market access

	(1)	(2)	(3)
Connection × access	0.110***	0.101***	0.205***
	(0.0378)	(0.0367)	(0.0721)
Connection × access × distance port	-0.0667*		
	(0.0400)		
Connection × access × market access		0.0369**	
		(0.0175)	
Connection × access × landlocked			-0.145*
			(0.0807)
Town FE	×	×	×
Country × year FE	×	×	×
GSM coverage	×	×	×
Geography controls × connection	×	×	×
Observations	2,310	2,310	2,310
Countries	10	10	10
Towns	210	210	210
Share treated	*.462*	*.462*	*.462*
Adjusted R^2	0.943	0.942	0.942

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Market access Market access has been identified as key complement to ICT (Freund and Weinhold, 2004). We therefore assess heterogeneity with respect to multiple market access measures in Table 2. First, we estimate the impact of a standard deviation increase in distance to the next port on the treatment effect by a triple interaction on SMC connection, internet availability, and (standardized) distance to port. The estimate suggests a statistically weakly significant negative effect of 6.6 percentage points reduced economic growth when distance to port increases by a standard deviation (290 km). Second, we calculate a market access measure following Baragwanath et al. (2021) from weighted geographic distances to a country's population as

$$\mathrm{MA}_i = \sum_{i \neq j} \frac{\mathrm{pop}_i}{(\mathrm{dist}_{i,j})^2}, \tag{3}$$

for each town j and settlements in the country i using the 2015 *Africapolis* location and population data. We exclude town j when calculating this measure (Donaldson and Hornbeck, 2016). Relative to the other measures used, this metric gives more weight to local and regional markets and less to distant but larger metropolitan areas. A standard deviation increase in this market access measure yields a 3.7 percentage point higher growth effect that is statistically more precisely estimated. As third proxy for market access, we use landlocked status on the country level and find a large but statistically only marginally significant heterogeneity. The point estimate suggests that the effect on towns in landlocked countries on average is only one quarter the size compared to towns in coastal countries. Together, the results on market access lack statistical power but point toward market access as a key complement to improved connectivity, in line with existing literature (see, e.g., Steinwender, 2018). Our findings suggests that the growth effect is present particularly in towns with local and regional market access, although international market access seems important too, e.g. for landlocked countries.

Transport infrastructure potentially affects economic growth (Boopen, 2006). As market access seems important for the growth effect of connectivity, other infrastructure is potentially complementary. We investigate heterogeneity with respect to road and railroad access in two ways. First, we estimate triple interaction models with distance to roads and railroads in Table B.6. Results show insignificant estimates implying no different effect for connected towns that are closer to infrastructure. Second, we vary our sample and include only towns with access to roads or railroads, finding similarly-sized and statistically indistinguishable effects. These results do not support a high relevance of transport infrastructure for harnessing the growth effects of connectivity. However, it is important to acknowledge limited statistical power due to the vast majority of sample towns being located alongside roads.[24] The significantly higher point estimate for towns with railroad access, where there is more variation in our sample, is suggestive of some relevance of transportation infrastructure.

Structural change ICT typically impacts sectors differently and is more complementary to services and manufacturing than agriculture (Acemoglu and Autor, 2011). We use individual-level employment from repeated cross-sectional surveys to investigate if internet availability is associated with different patterns of structural transformation. For five SSA countries, there is a survey for both before and after SMC arrival.[25] Data is geolocated at sub-national regional level. Therefore, we switch to the regional level for this analysis

[24] Note that this is a direct result of our empirical strategy focusing on on-route towns and a reassuring property of the sample.

[25] [[Countries, table appendix with survey years.]]

and define treated regions as regions with at least one access point during the observation period. Figure C.16 plots regional employment shares by sector and treatment status. Agricultural employment dominates with over two thirds of respondents, followed by services and manufacturing employment.

Regression results of our baseline model with industry shares as outcome show that regions with internet availability experience a shift in employment shares different to regions with no internet availability. Specifically, regions with internet availability at the time of SMC arrival feature an about 1.3 percentage point higher share of manufacturing workers in the survey after countrywide SMC connection. Given the spatial and temporal coarseness of the available data and the large informal sector, the marginal statistical significance of this finding is expected. While no economically and statistically meaningful effect is detected for service employment, there is an economically significant reduction in agricultural employment, although statistically insignificant. Overall, these results suggest a slightly faster structural transformation of regional economies toward manufacturing employment in connected regions. With manufacturing employment only at 11% on average, a 1.3 percentage-point increase reflects a sizable employment-based growth of 12% of the manufacturing sector.

Table 3: Internet availability and sectoral employment

Sector:	(1) agriculture	(2) manufacturing	(3) services
Connection × access	-0.0194	0.0129*	0.00642
	(0.0163)	(0.0074)	(0.0107)
Region FE	×	×	×
Country × year FE	×	×	×
GSM coverage	×	×	×
Observations	956,454	956,454	956,454
Countries	5	5	5
Regions	99	99	99
Share treated	*.208*	*.208*	*.208*
Adjusted R^2	0.128	0.039	0.100

Notes: Employment shares are measured at the region level. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, IPUMS International, Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

5.2 Robustness

Measurement Measurement is a key challenge in our setting (cf. section 3). Therefore we conduct a battery of robustness checks with respect to the measurement choices implicit in our preferred specification. Importantly, we vary our choice regarding the buffer around built-up areas (Table B.10), the population threshold for nodal cities (Table B.16 and Table B.17), and the required distance to an access point (Table B.20 and Table B.19). Furthermore, we re-estimate our baseline model using different specifications to measure the intensive margin growth effect (Table B.7) and on a larger sample, relaxing our requirement for town-level NTL data every year (Table B.11 and Table B.12). All robustness checks are extensively discussed in the dedicated subsection A.3 in the Appendix. Our checks demonstrate the robustness of the results with respect to measurement choices.

Omitted variables Factors affecting the outcome and correlated with treatment are a potential threat to identification. In our context, parallel infrastructure rollout is a potential concern. Other infrastructure that boosts local economic activity and is built in treatment but not control towns at the time of SMC arrival confounds our estimates. Except for mobile internet infrastructure, time-varying local infrastructure data are unfortunately unavailable. Therefore, we resort to alternative ways to assess robustness for possibly growth-enhancing infrastructure other than mobile connectivity.

Mobile connectivity. Our main specification already accounts for changing connectivity due to improved mobile signal. Generally, fiber infrastructure improves mobile signal as well, but at the time most cell towers in rural SSA are too far from the fiber network and relied on satellite or microwave transmission technology (Ngari and Petrack, 2019). In Table B.22, we additionally account for the possibility of time lags before improved mobile connectivity affects economic activity. We achieve this by introducing lagged mobile GSM coverage to the model. Results show that the main effect remains robust in all lag specifications. The strongest effect of mobile coverage on economic growth is estimated with a lag of one year. Afterward, the point estimate shrinks and loses statistical significance.

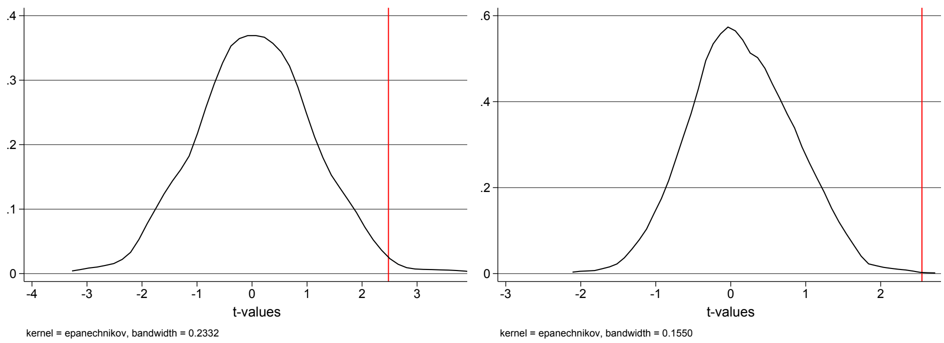
Electricity. Electricity is often found growth-enhancing in developing countries (see, e.g., Best and Burke, 2018; Rud, 2012). Consequently, simultaneous rollout of the electricity grid in treated but not control towns might be a thread to isolate the effect of internet availability. Their stable NTL emission of towns in our sample suggests electricity availability in the whole period (Falchetta et al., 2020; Dugoua et al., 2018). Nevertheless, to empirically test for spatial and temporal simultaneity, we draw on georeferenced survey data from *Afrobarometer* (BenYishay et al., 2017).[26] From the repeated cross-sections, we select data from the first four rounds of the survey between 1999 and 2009.[27] We aggregate household-level electricity availability to the town level and estimate our baseline model with town-level electricity availability either weighted and unweighted by sample size. The resulting samples are small both in terms of towns and countries. We therefore relax other sample restrictions. The specification and data are discussed in detail in subsection A.3. Results provide no indication for an overlap in the expansion of electricity grid and internet backbone. Additionally, we estimate a triple interaction model with distance to the electricity grid in column (3) of Table B.6 to assess effect heterogeneity with respect to electricity access and find an insignificant on growth.

[26] *Afrobarometer:* `https://afrobarometer.org/`, accessed 07/12/2022.

[27] We restrict the data to country-years to the time before the major SMC upgrades.

Placebo tests. Identification concerns regarding simultaneous expansion of other infrastructure are warranted only if they affect economic growth in treated but not control towns at the same time as a SMC arrives in a country. This means that simultaneous infrastructure rollouts nationally for internet and other infrastructure alone, for which we find no evidence, does not threaten our empirical design. The growth effect of simultaneously rolled-out infrastructure additionally would have to be systematically related to SMC arrival, which we consider highly unlikely. To assess empirically to what extent the captured effect is indeed specifically related to our empirical design we conduct two types of placebo exercises relating to the exogenous variation from national backbone rollout and SMC arrival.

Figure 4: Access and connection placebos



(a) access placebo **(b)** connection placebo

Note: The figure depicts the estimated kernel density function for the t-test statistics of the main effect for 1,000 permutations of our baseline specification with randomly assigned treatment years. *Sources:* Africa Bandwidth Maps, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

For the first placebo, we randomly assign treatment status to towns while maintaining each country's connection date. We then follow Chetty et al. (2009) and re-estimate our preferred specification on 1,000 permutations. Panel (a) of Figure 4 plots the density distribution of the resulting t-statistics. The vertical red line indicates the t-statistic of the estimate from our preferred (true) specification. The t-statistics of the randomly assigned hypothetical access samples are normally distributed and center around zero. Only in 18 of 1,000 permutations of internet access (1.8%) a higher t-statistic than in the true sample is observed. Similarly, we conduct a second placebo exercise randomly allocating the country connection years. Again, the distribution of t-statistics for 1,000 permutations plotted in panel (b) of Figure 4 is normally distributed, centering around zero. Only 1 out of 1,000 permutations (0.1%) yields a higher t-statistic than our true estimate. This implies the effect we find is statistically highly specific to both the exact timing of country-wide SMC arrival and town-level internet access at the time of SMC-arrival. Alternative growth-enhancing shocks are therefore unlikely to drive our effect if they do not exhibit a very similar structure both temporally and spatially.

Model specification We assess robustness regarding model specification in various ways. Importantly, our empirical design considers a selected sample of treated and control group towns following a conservative approach focused on clean identification. The difference-in-differences setting generally allows for different outcome levels and relies on the same underlying trends assumption. We already established that treated towns are somewhat larger; see Figure C.13. Nevertheless, common event study pre-trends point toward a robust design.

Sample balance. Still, a potential concern is that initially connected towns differ in terms of an economically more favorable location. The exogenous shock is at the country level and in Figure C.1 we point out that the timing of the countrywide internet connection is associated with countries' rollout progress. As the rollout of national internet networks is not random, we test whether observable time-invariant geographic controls correlate with treatment status in the cross section, given country fixed effects. If treatment status cannot be predicted from the controls, this adds additional credibility to our identification as it implies a like-for-like comparison. Figure C.5 show results of cross-sectional balance tests with respect to initial internet access. Internet access point rollout typically follows existing (transportation) infrastructure. Unsurprisingly, we therefore find a negative correlation between initial access and distance to capital cities, roads, and railroads. Our preferred specification includes all of these geographic factors interacted with the connection indicator to allow for changes in their importance for economic growth over time. There is no statistically significant correlation with other observables such as geographical characteristics and points of interest like educational or health infrastructure (Figure C.5 and Figure C.4).[28] We conduct a similar balance test at the country level using (weighted) averages of the same observables and their relation to connection year. We report the largely similar results in Figure C.6.

Control group. Designing a control group from towns getting an access point only after the post-treatment observation period ensures access points established near or in control towns during the post-treatment period do not contaminate the control group. However, this design also leads to a gap in the connection years between treated and control towns. In Table B.21 we re-run our baseline model not allowing late connected towns in the control group to have access points after certain calendar years (columns (1) to (4)) and with different post-SMC cutoff years (columns (5) to (7)). Although this significantly impacts sample size, the effect remains relatively stable and significant. Going into the other direction, relaxing this restriction further by allowing also late-connected or (to date) untreated towns in the control group increases sample size. Results are robust to these changes, too, and are reported in columns (2) and (3) of Table B.10.

Further specifications. National backbone expansion typically focus on major trade routes from the landing point in or near the capital to the second-largest economic center such that the treatment group often includes towns on these routes. Our baseline specification controls for town fixed effects as well as changes in importance of geography over time. At the same time, heterogeneity analyses points to market access as

[28] An exception are colleges, which show a marginally significant association with treatment status. At the same time, other educational infrastructure such as universities and schools are insignificantly related to treatment status.

important amplifier of the growth effect of connectivity. In column (3) of Table B.9 we exclude towns on a countries' main trade corridor to address concerns the effect is purely driven by a selected group of favorably located towns. Despite significant reduction in sample size, the effect remains stable. We provide more detail and report further robustness tests with respect to model specification in subsection A.3 in the Appendix. These include econometric model choice like standard error clustering, effect stability regarding countries, and additional industry heterogeneity results.

6 Conclusion

Digital infrastructure is a key precondition for locations to harvest digital dividends from internet connectivity. In rural areas of SSA, infrastructure provision is particularly costly due to remoteness and low population density. At the same time, due to differences in the structure of rural economies it is unclear if such locations are able to reap similarly high benefits from connectivity and therefore if closing the digital divide simultaneously narrows the economic gap between rural areas and economic centers. In this study, we exploit the unique setting when internet first became available in SSA with the arrival of sub-marine cables during the 2000s. We show that even low-speed internet predominantly accessed in community based internet centers, cybercafés, significantly improves economic development of remote towns in rural SSA.

In particular, we study the arrival of the first sub-marine internet cables in ten SSA countries in the 2000s, which first brought international bandwidth and therefore internet connectivity to SSA countries. We assess the causal effect of internet availability on local economic growth using a difference-in-difference setup that additionally makes use of the rollout of national backbone infrastructure to design appropriate treatment and control groups. Our quasi-experimental comparison relies on incidentally connected towns on-route between economic centers connected by national internet backbones at the time of country-wide internet arrival. Together with plausibly exogenous variation in the timing of SMC arrivals, this allows us to causally estimate the effect of internet availability by comparing initially connected on-route towns to a control group of similar towns not (yet) connected to the national digital infrastructure but that get an access point later. In this comparison, we track economic activity of each town using nighttime lights as a proxy measure.

We find that the connection of remote towns in SSA to the *World Wide Web*, on average, leads to an increase in light emissions of about 11 percent, relative to similar towns not (yet) connected. This translates into about 3.3 percentage points higher growth in terms of GDP. Moreover, we decompose light emissions into growth in lit pixels (extensive margin), and in light intensity (intensive margin) and find higher significance for intensive-margin growth. Together with an assessment of changes in population showing no effect, this is more in line with growth in per capita productivity in connected towns rather than a spatial redistribution of economic activity. Further analyses suggest higher effects in towns with better market access and show local internet availability is associated with a shift in regional employment shares toward manufacturing.

Overall, our results suggest significant effects even of low-speed internet in remote towns in rural SSA that are predominantly served via cybercafés.

Our findings have several implications for policy makers. Importantly, that internet infrastructure drives economic growth in remote towns beyond the large urban areas of developing countries. Internet infrastructure investments therefore are an important lever for regional development policy aiming to narrow the digital and economic divide within the developing world. When planning national backbone expansions, decision makers should take into account positive spillovers of connectivity on smaller, on-route towns and consider maximizing the number of access point along routes between nodal cities of the backbone. Evidence suggests there is a complementarity between internet infrastructure and market access. Moreover, our findings point to significant economic growth effects even with low-speed internet and through a low-cost local access mode that does not require high investments in 'last mile' infrastructure.

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A Supplemantary Information

A.1 Country example: Benin

To understand national backbone rollouts in SSA countries in more detail, we describe the case of Benin as a typical example. Benin is one of the countries connected via the SAT-3 SMC, which brought an international connection of 45 Mbps (Chabossou, 2007). The rollout of the national backbone was planned by Benin Telecoms SA, the fixed-line monopolist who manages the gateway to the national Internet, operates as the national carrier, and administers the national domain (*.bj). Benin Telecoms SA is state-owned and offered permanent ADSL connections with up to 2 Mbps at the time (Agyeman, 2007).

Infrastructure rollout According to Chabossou (2007), the SAT-3 SMC landed in Cotonou, Benin's largest city, the seat of government, and located 40 kilometers away from Benin's official capital, the much smaller city of Porto-Novo. Close by, in Abomey-Calavi, Benin's largest digital hub is located as well. Together with Godomey, these cities form the largest agglomeration and metropolitan area in Benin with nearly 2.5 million inhabitants, which represents about a third of Benin's population. From there, first, a connection to Parakou with a 425 kilometers optical fiber cable was constructed in 2001. Parakou is Benin's next largest economic center with more than 150,000 inhabitants in the 2002 census and the capital of the Borgou department. This connection was constructed along Benin's railway line and roads network (Figure C.14). On its way, the backbone cable connected smaller, more remote towns such as Savalou with 30,000 inhabitants. The next national backbone connection was established between Parakou and the borders to Niger, in the north-east, and Burkina Faso, in the north-west. These connections were constructed along the road network and transformed Benin to a sub-regional digital hub interconnecting Togo, Nigeria, Burkina Faso, and Niger. Until 2001, only the first kilometers of the fiber-optic backbone and access points were under construction. 2001 was the year of most active national backbone development in Benin. Benin Telecoms SA's infrastructure investment peaked in 2001, with more than USD 80 billion. The connection to Burkina Faso and Togo was constructed through Natitingou, the capital of the Atakora department. Again, on-route remote towns like Kandi or Djougou were connected incidentally. Only later, during the construction of cross-links in the national backbone, further rural towns were connected. Cross-links are often added to hub-and-spoke networks to increase network resilience and reliability through redundancies. In Benin, remote towns like Nikki, Ségbana, and Banikoara benefited from incidental connection through cross-links.

Internet use In Benin, Benin Telecoms SA owns the transmission monopoly. Benin Telecoms SA, at the time, offered data transmission packages mostly to commercial clients (banks, hotels, ministries, etc.). The broader population mostly accessed the internet through cybercafés in the 2000s (cf. subsection A.2). The number of cybercafés grew exponentially with internet infrastructure rollout in Benin and reached several thousands. In contrast to international institutions, universities, or major corporations, private individuals typically do not have home access (Chabossou, 2007). Still, in 2006 only 25 percent of Benin's population had used the internet at least once. Access is mainly at cybercafés (21 percent) or at the workplace (2.2 percent), while internet at home remains expensive (Ahoyo, 2006).

A.2 Cybercafés and 'last mile' technologies

As in most developing countries, internet in SSA countries before the era of smartphones was largely accessed through cybercafés (see, e.g. Osho and Adepoju, 2016; LeBlanc and Shrum, 2017; Southwood, 2022), especially in the rural areas (Williams et al., 2012). Cybercafés (also: internet cafés; or just: cyber) in rural SSA are community-based internet centers typically in the form of small shops or rooms with one or two computers with internet access (see, e.g. LeBlanc and Shrum, 2017; Mbarika et al., 2004), though larger cybercafés exist in cities (LeBlanc and Shrum, 2017). The photograph in Figure C.3 shows an example of a rural cybercafé. Cybercafés represented the first experience of going online for most people in SSA who used the internet during the 2000s and early 2010s (Lubwama, 2023) and became hubs for communication, research, and online entertainment (Kitimbo, 2023). Alternative (public) access points like libraries or telecenters were relatively rare (Gomez, 2014).

Other 'last-mile' technologies at the time offered only unstable connection and were limited and prohibitively expensive. Dial-up in via 56k modems is only possible in locations connected to the telephony network and therefore mostly restricted to selected neighborhoods or places in larger cities (Gitta and Ikoja-Odongo, 2003). In 2004, average costs of a dial-up internet account for 20 hours a month in Africa were prohibitively expensive for most households with around USD 68 per month (Mbarika et al., 2004). Internet connection via satellite (e.g., Very Small Aparture Terminals; VSAT) was even more costly while providing less stable connectivity, although available independent from telephony networks (McKague et al., 2009; Nyezi, 2012; Byanyuma et al., 2013). In contrast, cybercafés have wired connections to the national backbone providing reliable signal at relatively high speed (LeBlanc and Shrum, 2017). Even when mobile internet became available around 2010, at first internet access on personal devices remained much more expensive compared to cybercafés (LeBlanc and Shrum, 2017).

In the 2000s cybercafés quickly became places to interact and exchange information with the outside world (Mbarika et al., 2004) as they provide affordable, immediate and convenient access to the internet (Osho and Adepoju, 2016). Users of cybercafés generally constitute a diverse group, although with a bias towards younger populations, especially educated males and local elites (Mwesige, 2004; Gitta and Ikoja-Odongo, 2003). Low-speed internet at 0.5-2 Mbps available in the 2000s allowed basic functionality such as web browsing, e-mail, and chat messaging but not video streaming or other data-intensive activities. In a 2003 survey in Uganda, users indicated the purposes of their internet use in cybercafés is communication via e-mail (89%), research (32%), entertainment (30%), education (27%), or sports and news (24%); a quarter of respondents indicated using the internet for trade and commerce (Gitta and Ikoja-Odongo, 2003). According to Williams et al. (2012), cybercafés are particularly important for rural internet access in Africa as they benefit small-scale knowledge-based businesses such as call centers, engineering companies, farmers, and other local firms relying on outside information. Similarly, Mbarika et al. (2004) acknowledges the role of cybercafés in Sub-Saharan Africa in maintaining business contacts. This is confirmed by ample anecdotal evidence. For example, in a blog post Ndiomewese (2015) writes:

> "Those days [early 2000s], you could almost certainly stroll into a cybercafé and meet the MD [managing director] of a bank in one corner working on his private laptop."

Around 2010, the era of internet access via cybercafés in SSA countries came to an end due to mobile internet (see, e.g. Olofinlua, 2015). With telecom companies starting to offer mobile-browsing packages and increasing adoption of internet-enabled mobile phones, an alternative to the "long queues, overstuffed rooms, [and] lack of privacy" in cybercafés established (see, e.g., Quadri, 2023). According to a survey in several African countries, by 2011/12 mobile internet was the most commonly used form to access the internet (Stork et al., 2014). Still today, for many people in SSA data can be prohibitively expensive and cybercafés remain a prominent way to access the internet for low-income families (Quadri, 2023).

A.3 Additional robustness analyses

NTL precision, blurring, and buffer In our main specification, we consider a buffer of 2 kilometers around built-up areas due to blurring of the NTL data (cf. Figure 2). In column (4) of Table B.21, we remove the 2 kilometers buffer and estimate on the original *Africapolis* built-up areas. This implies we lose pixels at the town borders, typically with lower light intensities. As a result, our sample shrinks as some towns feature lit pixels only outside the built-up area but within the 2 kilometer buffer zone. This also leads to losing the country Angola.[29] An advantage of this approach is that blurring spilling over from nearby agglomerations is less prominent. Note that this is a marginal problem as we consider remote towns. The main effect, in comparison to the relevant baseline sample specification in column (2) of Table B.4 is robust with a slightly higher point estimate. With this robustness check, we show that our results do not depend on the adjustment of the built-up area. It also suggests that local light emissions originate predominantly at the town center rather than its outskirts.

We elicit economic growth of towns from changes in NTL emissions. In the main specification, we require stable NTL emission of towns over time and restrict our sample to towns with light emission in all years after 1994 (the earliest year in the sample). This ensures we capture meaningful changes in local light emissions. As this comes at the expense of sample size, we relax this restriction and conduct two types of robustness analyses. First, in Table B.11, we allow the sample to have missing light emission in up to three years at any point in time. In columns (1) through (4) there is no other restriction, while the specifications in columns (5) through (8) further require stable light emission in early years. Sample size and the number of countries increases when allowing for more missing NTL years. Results remain remarkably

[29] Estimating on the sample of the main specification without Angola is shown in column (2) of Table B.4. The sample shrinks, but the main effect estimate remains stable.

robust, yet some feature slightly smaller point estimates and are less precisely estimated. We therefore estimate alternative specifications with imputed values in Table B.12, which improves statistical power on the estimates compared to Table B.11. While these techniques allow to include more and even smaller towns, it comes at the expense of precision and pushes the NTL data to its limits. We therefore prefer our baseline model featuring a sample of towns with stable NTL emission over time.

Nodal cities Generally, classifying agglomerations into subgroups is a debated topic and depends on many factors such as the country context and development (see, e.g., Frey and Zimmer, 2001). For our classification of nodal cities, we follow Dijkstra et al. (2020), who classify cities as agglomerations with more than 50,000 inhabitants. Note that we do not consider population density as a second criterion. Our sample of towns also coincides well with the definition of Dijkstra et al. (2020) (between 5,000 and 50,000 inhabitants). Still, the threshold for nodal cities is somewhat arbitrary. Therefore, we present robustness analyses in Table B.16 and Table B.17. In Table B.16, we vary the absolute cutoff value around our preferred definition and present alternatives ranging from 30,000 to 100,000 inhabitants. Results are very stable and tend to become slightly larger when more large towns are excluded, providing reassurance that we do not include unreasonably large towns. Yielding similarly robust results, Table B.17 presents specifications using percentile thresholds.

Internet access Our interviews with experts at *Africa Bandwidth Maps* suggest an average distance of 10 kilometers to access points is an appropriate proxy for internet availability, given the transmission technology used predominantly at the time.[30] Consequently, in our main specification we define towns with an access point to the national backbone within 10 kilometers as within-reach, i.e., having access to internet infrastructure. Note that, in general, internet infrastructure availability is best interpreted as intention-to-treat effect. Some sources (e.g., Ngari and Petrack, 2019) suggest access points have a wider average range up to 50 kilometers, depending on geographical characteristics. In Table B.19, we estimate heterogeneous effects for towns within 10, 10-30, and 30-50 kilometer distance of an access point, respectively. Results show the effect is present for towns within 10 kilometers and decreases but remains statistically significant, though on a lower level, for towns within 10-30 kilometers. There is no measurable effect for towns within 30-50 kilometers.

In Table B.20, we re-estimate our baseline model using alternative distance thresholds of 5, 7.5, 12.5, and 15 kilometers. Note that the distance threshold affects the sample. Specifically, the control group shrinks when allowing for higher distances. For identification, it is important that the treatment group contains only towns with internet infrastructure access while the control group has no access. Too low distance thresholds potentially violate the first condition; too high distance thresholds might lead to wrong attribution

[30] In their own analyses of population catchment areas from 2009 onward, *Africa Bandwidth Maps* use 10, 25, and 50 kilometer distances, respectively, for different scenarios. During the 2000s, the early years of national backbones in SSA, we opt for 10 kilometers.

of treatment status to suitable control towns. Results show a stable effect throughout all specifications. The slight reductions in point estimates and statistical power suggest our preferred specification is appropriate.

Clustering A potential concern is that model errors are spatially correlated within regions. Whenever more than one town is located within 10 kilometers to the access point, an access point serves more than one town. Therefore, we cluster at the access point level in our preferred specification. Yet, most treatment and control group towns do not share an access point and are also not located close to one another. Moreover, access points might generate spillover effects in surrounding areas. To take this into account, we apply a higher level of clustered standard errors in column (2) of Table B.14 using the administrative units of states (Admin-1). In addition, we re-estimate our baseline model with grid cell level clustering at one- (column (3)) and three-degree (column (4)) grid cells, a frequently applied alternative clustering method (see, e.g., Hjort and Poulsen, 2019). Reassuringly, all specifications yield close to unchanged results with barely moving confidence intervals.

Fixed effects In our baseline specification, we apply country-year fixed effects to account for country-specific growth paths. For robustness, we relax fixed effect granularity and re-estimate our preferred specification with the classical two-way fixed effects (TWFE) only: towns and calendar years. This specification is less demanding in the set of fixed effects. A potential concern with a TWFE specification might be that countries on a higher growth path might construct more access points faster. Therefore, this specification serves as a robustness check and not as the main specification provided in column (1) of Table B.10. At the same time, it significantly increases the sample. With TWFE, the estimate significantly increases. As we consider country-specific growth trends likely, we opt for the more conservative set of fixed effects in our main specification.

Control group Our baseline specification relies on a fairly conservative design of control (and treatment) group focused on identification. As a result, a potential concern might be that this imposes unnecessarily strict restrictions on our sample. In columns (2) and (3) of Table B.10, we therefore extend our sample by easing some restraints. In column (2), we allow towns that did not receive an access point until the end of our data period in 2020 in the control group. This increases our sample significantly both in terms of towns and countries. Although we show that the type of towns we study incidentally get access due to their on-route location, one might have concerns with this specification regarding potential selection issues. Results corroborate the validity of our empirical design and external validity as the estimates remain unaffected while sample size increases. Nevertheless, for our baseline specification we stick with the more restricted sample for cleaner identification.

In column (3) of Table B.10, we extend the sample by adding towns to the control group that were connected during the five-year period after connection. In our main specification, these towns are excluded as they neither belong clearly to the treatment nor the control group and would thus confound our analysis. However, given our finding that the effect of internet on growth materializes with a lag of two to three years, these towns are unlikely to exert a strong confounding effect on our results. At the same time, they significantly increase our sample size as well as the number of countries. With this specification, results remain robust and show a highly significant and only slightly smaller effect. As this could be due to some confounding, we stick with our baseline specification excluding towns receiving access in the post-period.

Although this reduces concerns regarding the suitability of our control group, a related concern might be that towns being connected through an access point which was constructed many years after the first internet connection are not comparable to the treated towns which were connected through an access point constructed before the first internet connection. We address this concern in Table B.21 by re-estimating our baseline specification restricting the control group to towns receiving an access point just after the five-year post period. We apply different levels of stringency to trade-off the resulting reduction in sample size and improved identification. Columns (1) through (4) use calendar year cutoffs while columns (5) through (7) apply cutoffs in years relative to countrywide connection. In line with the notion of incidentally connected on-route towns, we find no strong impact on our estimate.

Our identification builds on the notion that the plausibly exogenous timing of SMC arrivals affects countries in different stages of their national backbone expansion. This implies some countries receive international bandwidth and therefore internet connection with little rural internet infrastructure while in other countries national backbone expansion already progressed to more regions. This is shown by Figure C.1, which plots progress in national backbone expansion against connection year for SSA countries. Although not strong, which is expected given the unpredictability of SMC arrival, we observe a positive relation, i.e., countries connected later progressed further in the expansion of national backbones when provided with international bandwidth. This supports our empirical strategy as it exemplifies the variation in national backbone access around treatment date.

Countries In our baseline specification, we rely on caparison within countries. Still, given the large variation in country sizes and country sample sizes, a potential concern might be to what extent our results are driven by selected countries. There is a considerable heterogeneity between landlocked and coastal countries (cf. subsection 5.2). Therefore, in Table B.4 we re-run iterations of our baseline regression and exclude each country in our sample. Similarly, in Table B.5 we re-estimate the effect for coastal countries. Results are remarkably robust across all specifications and remain statistically significant at the 1%-level. This is not only reassuring with respect to the presence of the effect in all countries contained in our sample, but also points to low effect heterogeneity across countries.

Employment Our heterogeneity analysis with respect to regional employment shifts using *IPUMS International* survey data features the same geography times connection controls as our baseline specification to allow for changes in the importance of geography over time. However, given the time resolution of the survey data is much less granular than years this specification might be too demanding. Therefore, in Table B.18 we omit the geography controls and instead rely on region and country-year fixed effects. The results remain unchanged for all sectors in significance, although point estimates consistently show slightly larger effects as measured in levels. This generally suggests robust effects. If anything, we slightly underestimate the effect strength in our more demanding main specification.

Ethnic favoritism A concern regarding our empirical model might be that certain ethnic groups were favored during rollout. Though the exogenous shock comes from countrywide connections and parallel trends in the event study do not underpin this concern, this would still be problematic if certain ethnic groups are also favored along other dimensions with the same timing, causing the observed growth differences over time. Using the map of ethnic boundaries by (Murdock, 1959) digitized by Weidmann et al. (2010), we extract the ethnic group majority in the area of each access point. Figure C.17 descriptively shows that many countries construct access points for more than one ethnic group before the treatment period. For the countries in our analysis, all countries except Angola provide at least two different ethnic groups with access points.[31] This already provides some indicates counter ethnic favoritism. Second, we construct country-ethnic group entities instead of countries. By re-estimating our baseline specification including town and country-ethnicity-year fixed effects, treatment and control group towns are compared only within a particular ethnic group. If ethnic favoritism drives our effects, the estimate in this specification is expected to vanish. The results are shown in column (5) of Table B.10. Naturally, sample size reduces in this more demanding specification. The result remains robust with a slightly lower point estimate, showing that even when comparing treatment and control group towns in areas with the same ethnic group majority, internet availability has a positive effect on local economic activity.

[31] Angola generally established few access points prior to connection.

B Tables

Table B.1: Connection years

Country	year	connection	landing point	upgrade
Namibia	1999	Neighboring country		2012
Djibouti	1999	Sub-marine cable	Djibouti City	2009
Senegal	2000	Sub-marine cable	Dakar	2010
Angola	2001	Sub-marine cable	Sangano	2012
Benin	2001	Sub-marine cable	Cotonou	2012
Ghana	2001	Sub-marine cable	Accra	2010
Cameroon	2001	Sub-marine cable	Douala	2012
Gabon	2001	Sub-marine cable	Libreville	2012
Nigeria	2001	Sub-marine cable	Lagos	2010
Ivory Coast	2001	Sub-marine cable	Abidjan	2010
Sudan	2003	Sub-marine cable	Port Sudan	2010
Mali	2004	Neighboring country		2010
Botswana	2004	Neighboring country		2009
Zimbabwe	2004	Neighboring country		2011
Burkina Faso	2005	Neighboring country		2010
Togo	2005	Sub-marine cable	Lomé	2012
Gambia	2005	Sub-marine cable	Banjul	2012
Chad	2005	Neighboring country		2012
Central African Republic (CAR)	2005	Neighboring country		2012
Guinea-Bissau	2005	Sub-marine cable	Suro	2012
Mozambique	2006	Sub-marine cable	Maputo	2009
Lesotho	2006	Neighboring country		2010
Niger	2006	Neighboring country		2012
Malawi	2007	Neighboring country		2010
Ethiopia	2007	Neighboring country		2012
Zambia	2007	Neighboring country		2011
Swaziland	2008	Neighboring country		2009

Notes: Table reports the connection years of all SSA countries being connected before 2009. *Sources:* Africa Bandwidth Maps, Submarine Cable Map.

Table B.2: National backbone expansions

Country	ISO	connection via	connection year	national backbone	notes
Angola	AGO	SAT-3	2001	concentrated on the big cities along the coast; some routes to larger cities within the country; landing point for submarine cable in capital city in north-west of country	after initial expansion prior to the arrival of the SAT-3 cable in 2001, network expansion in AGO was non-existent until the African Cup (football) in 2010
Benin	BEN	SAT-3	2001	network expansion mainly to larger cities and towards border connection points with neigboring countries; landing point for submarine cables in south	access point at the border with BFA were present since 2009, but the actual connection was established as late as 2017 due to conflicts about land titles in the border area
Botswana	BWA	ZAF	2004	network expansion mainly to larger cities and state capitals as well as border points; denser network in the east, where larger cities and the capital are located; connection via south-easter border with ZAF	
Burkina Faso	BFA	SEN-MLI	2005	network is expanded focused on routes necessary for international conection and border points to further neigboring countries	access via SEN and MLI instead of the geographically more convenient CIV or GHA; civil unrest in CIV at the time
Cameroon	CMR	SAT-3	2001	network present in largest cities; landing point in capital city	network extends along an oil pipeline between CMR and TCD, with a stop in CAF; this route encompasses most of the CMRs backbone and connects TCD and CAF
Chad	TCD	CMR-CAF	2005	network limited to south-west, the location of the capital; border connection close to capital	
Côte d'Ivoire	CIV	SAT-3	2001	extensive network expansion in the south but limited in the north; overall expansion mainly to larger cities	civil war during the early 2000s hindered network expansion to the north and made international connection through CIV unfeasible
Djibouti	DJI	SEA-ME-WE-3	1999	network expansion to larger cities as well as the border with ETH	no connection of neighboring countries until 2007 despite early connection

Table continues on the next page.

Country	ISO	via	year	national backbone	notes
Eritrea	ERI	EASSy	2009	network expansion to limited number of larger cities	connected only in 2009 via the EASSy cable, long after all neighbor countries established somewhat extensive networks; there were border conflicts with ETH
Ethiopia	ETH	SDN	2007	network centered around capital and limited in Eastern regions	
Gabon	GAB	SAT-3	2001	small network; landing point in capital located in north-west	
Gambia	GMB	SEN	2005	network expansion along river, where larger cities are located	
Ghana	GHA	SAT-3	2001	extensive network expansion in the south; connections at northern border points only very late; landing point in capital at southern coast	
Guinea-Bissau	GNB	SEN	2005	no network expansion; connection from Senegal	
Kenya	KEN	TEAMS	2009	network expansion focussed on south, except for larger cities in the north; landing point in capital	initiated a bilateral cable project with the UAE; although plans started as early as 2003, cable established in 2009, few years before the major multinational cable projects; therefore a unusually large part of the network established prior to sub-marine cable connection
Lesotho	LSO	ZAF	2006	network covers largest cities	
Madagascar	MDG	LION	2009	network covers the larger cities at the coasts	
Malawi	MWI	ZAF-MOZ	2007	network focused on the south	
Mali	MLI	SEN	2004	extensive network expansion with focus on populated south; few connections to the north	important transit country as connections from SEN run through MLI to the countries that could not connect via CIV or GHA

Table continues on the next page.

Country	ISO	via	year	national backbone	notes
Mozambique	MOZ	ZAF	2006	extensive network expansion all over the country, but less dense in south	network expansion between major cities in the south prior to international connection via ZAF was established; connections between capital and larger cities are made through domestic submarine cables
Namibia	NAM	ZAF	1999	extensive and early network expansion all over the country, with connections to all borders	extensive network expansion before the international connection was established
Niger	NER	BEN	2006	small network focussed on south, the location of the capital	
Nigeria	NGA	SAT-3	2001	extensive network expansion all over the country with connections to all borders; especially dense in coastal areas and around capital; landing point in south close to largest city	connection to NER in the North-west constructed on usually direct, straight route, leaving out some bigger cities
Rwanda	RWA	KEN-UGA	2009	network expansion to all regions	
Senegal	SEN	Atlantis-2	2000	network expansion to largest cities; landing point in capital	network partially present prior to international connection
South Africa	ZAF	SAT-2	1993	very dense network all over the country; two landing points for submarine cables	
Sudan	SDN	SAS-2	2003	network expansoin to all regional capitals; more dense in the east and along the Nile river; landing point at largest port	
Swaziland	SWZ	ZAF	2008	network covers largest cities	
Tanzania	TZA	EASSy	2009	network expansion with focus on the coast, but covers all major cities and regional capitals; landing point in capital	network expansion mainly prior to international connection
Togo	TGO	SEN-MLI-BFA	2005	network expansion from inland border with BFA to capital city at the coast	obtained connection via BFA instead of an own landing point or via NGA or GHA
Uganda	UGA	KEN	2009	network expansion centered around capital	network expansion mostly prior to international connection

Table continues on the next page.

Country	ISO	via	year	national backbone	notes
Zambia	ZMB	EASSy	2007	extensive network expansion all over the country	state-owned electricity grid operator used pre-existing powerlines to establish an unusually dense network
Zimbabwe	ZWE	ZAF	2004	network expansion covers larger cities and connections to border points	

Sources: Table D.23, Africa Bandwidth Maps, own research.

Table B.3: Summary statistics

	(1) Mean	(2) SD	(3) Min	(4) P25	(5) P50	(6) P75	(7) Max
Population							
in 2000	15,956.67	13,154.77	0.00	5,398.00	12,772.00	24,239.00	49,217.00
in 2015	36,504.72	27,033.93	10,209.00	17,156.00	28,011.00	46,439.00	205,943.00
Density (2015)	4,860.99	4,118.79	710.00	2,639.00	3,982.00	6,029.00	38,637.00
Agglomeration							
Built-up area (2015)	10.99	12.29	0.35	4.40	7.40	13.47	122.21
Light intensity (in t-1)	505.41	601.41	12.00	174.00	308.00	585.00	4,842.00
Light intensity (in t-1, avg.)	7.05	5.99	0.29	3.10	4.82	8.91	32.72
Geography							
Altitude	874.76	719.08	0.02	60.20	1,016.20	1,372.18	2,816.32
Distance to							
Capital	2.52	2.48	0.02	0.75	1.75	3.59	12.54
Coastline	3.70	2.89	0.00	0.94	3.84	5.47	11.57
River	0.57	0.52	0.00	0.15	0.47	0.91	3.36
Landing point	5.64	3.85	0.01	1.74	6.02	9.02	14.510
Road	0.03	0.12	0.00	0.00	0.00	0.00	1.13
Rrailroad	0.58	0.93	0.00	0.00	0.07	0.85	4.40
Border	1.20	1.21	0.00	0.20	0.85	1.77	5.02
Port	4.02	2.90	0.00	1.35	4.29	5.87	11.96
Electricity grid	0.12	0.32	0.00	0.00	0.00	0.05	2.25
Terrain ruggedness	10.60	1.63	0.00	9.80	10.84	11.63	13.36
Market access	14804589.90	107781232.19	119.00	1,256.00	4,987.00	12,922.00	988349824.00
Connectivity							
Distance to access point (2020)	1.28	2.58	0.00	0.00	0.00	1.13	9.43
Mobile coverage (in t-1, GSM)	0.59	0.48	0.00	0.00	1.00	1.00	1.00

Notes: Table reports summary statistics for the estimation sample. *Sources:* Africa Bandwidth Maps, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.4: Robustness: country exclusion

Excluded country:	(1) AO	(2) BJ	(3) BW	(4) ET	(5) MW	(6) MZ	(7) SD	(8) SN	(9) ZM	(10) ZW
Connection × access	0.0908***	0.104**	0.113***	0.163***	0.111***	0.111***	0.103***	0.103**	0.113***	0.0817**
	(0.0313)	(0.0441)	(0.0390)	(0.0473)	(0.0396)	(0.0395)	(0.0391)	(0.0424)	(0.0401)	(0.0399)
Town FE	×	×	×	×	×	×	×	×	×	×
Country × year FE	×	×	×	×	×	×	×	×	×	×
GSM coverage	×	×	×	×	×	×	×	×	×	×
Geography controls × connection	×	×	×	×	×	×	×	×	×	×
Observations	2,200	2,057	2,200	1,859	2,222	2,200	2,211	2,002	2,101	1,738
Countries	9	9	9	9	9	9	9	9	9	9
Towns	200	187	200	169	202	200	201	182	191	158
Share treated	.48	.46	.44	.467	.47	.455	.478	.407	.455	.513
Adjusted R^2	0.945	0.945	0.938	0.947	0.942	0.941	0.944	0.942	0.941	0.930

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.5: Robustness: coastal country exclusion

	(1)	(2)	(3)	(4)	(5)	(6)
Excluded country:	AO	BJ	MZ	SD	SN	TG
Connection × access	0.220***	0.278**	0.338***	0.284***	0.299***	0.287***
	(0.0506)	(0.112)	(0.0742)	(0.0734)	(0.0881)	(0.0724)
Town FE	×	×	×	×	×	×
Country × year FE	×	×	×	×	×	×
GSM coverage	×	×	×	×	×	×
Geography controls × connection	×	×	×	×	×	×
Observations	836	748	902	935	715	979
Countries	5	5	5	5	5	5
Towns	76	68	82	85	65	89
Share treated	.605	.5	.5	.541	.369	.494
Adjusted R^2	0.908	0.919	0.888	0.901	0.901	0.896

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.6: Heterogeneity: infrastructure distance

	(1)	(2)	(3)	(4)	(5)
Connection × access	0.115**	0.107**	0.115***	0.119***	0.0949**
	(0.0490)	(0.0440)	(0.0437)	(0.0451)	(0.0466)
Connection × access ×					
distance roads	0.0306				
	(0.120)				
distance railroads		-0.0224			
		(0.0302)			
distance electricity grid			0.0765		
			(0.0492)		
distance border				-0.0421	
				(0.0508)	
distance capital					-0.0246
					(0.0541)
Town FE	×	×	×	×	×
Country × year FE	×	×	×	×	×
GSM coverage	×	×	×	×	×
Geography controls × connection	×	×	×	×	×
Observations	2,310	2,310	2,310	2,310	2,310
Countries	10	10	10	10	10
Towns	210	210	210	210	210
Share treated	*.462*	*.462*	*.462*	*.462*	*.462*
Adjusted R^2	0.943	0.942	0.942	0.942	0.942

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.7: Measurement: intensive margin

		pixel intensity				
	(1) lit 1995	(2) top 10%	(3) top 20%	(4) top 30%	(5) top 40%	(6) top 50%
Connection × access	0.0821**	0.0533*	0.0600**	0.0674**	0.0693**	0.0705**
	(0.0316)	(0.0280)	(0.0297)	(0.0311)	(0.0329)	(0.0337)
Town FE	×	×	×	×	×	×
Country × year FE	×	×	×	×	×	×
GSM coverage	×	×	×	×	×	×
Geography controls × connection	×	×	×	×	×	×
Observations	2,310	2,310	2,310	2,310	2,310	2,310
Countries	10	10	10	10	10	10
Towns	210	210	210	210	210	210
Share treated	*.462*	*.462*	*.462*	*.462*	*.462*	*.462*
Adjusted R^2	0.923	0.963	0.959	0.955	0.951	0.949

Notes: Table reports variations of intensive NTL measures. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.8: Census years

Country	**connection**	**2010s**	**2000s**	**1990s**
Benin	2001	2013	2002	1992
Ethiopia	2007	n.a.	2007	1994
Malawi	2007	n.a.	2008	1998
Mozambique	2006	n.a.	2007	1997
Zambia	2007	2010	2000	1990

Notes: Table reports available survey waves by country used in our analysis as well as their year of connection via SMC or neighboring country. *Sources:* IPUMS International, Submarine Cable Map.

Table B.9: Heterogeneity: transport infrastructure

Sample:	(1) road access	(2) railroad access	(3) non-main
Connection × access	0.107**	0.155**	0.0843**
	(0.0438)	(0.0672)	(0.0332)
Town FE	×	×	×
Country × year FE	×	×	×
GSM coverage	×	×	×
Geography controls × connection	×	×	×
Observations	1,892	957	2,024
Countries	10	10	10
Towns	172	87	184
Share treated	.465	.529	.418
Adjusted R^2	0.941	0.963	0.920

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.10: Robustness: control group

Sample:	(1) relax FE	(2) untreated	(3) all late	(4) no buffer	(5) ethnic
Connection × access	0.227***	0.105***	0.0976***	0.0835**	0.0933**
	(0.0424)	(0.0368)	(0.0357)	(0.0373)	(0.0364)
Town FE	×	×	×	×	×
Year FE	×				
Country × year FE		×	×	×	
Country × ethnicity × year FE					×
GSM coverage	×	×	×	×	×
Geography controls × connection	×	×	×	×	×
Observations	3,883	4,345	3,707	2,178	1,793
Countries	20	13	13	11	10
Towns	353	395	337	198	163
Share treated	.309	.268	.315	.455	.454
Adjusted R^2	0.916	0.937	0.944	0.981	0.946

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.11: Measurement: missing NTL years

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Missing years allowed:	0	1	2	3	0	1	2	3
Connection × access	0.101**	0.109***	0.0924**	0.0708*	0.109***	0.0897**	0.0833*	0.0853**
	(0.0448)	(0.0394)	(0.0388)	(0.0395)	(0.0383)	(0.0399)	(0.0426)	(0.0431)
Town FE	×	×	×	×	×	×	×	×
Country × year FE	×	×	×	×	×	×	×	×
GSM coverage	×	×	×	×	×	×	×	×
Geography controls × connection	×	×	×	×	×	×	×	×
NTL in early years					×	×	×	×
Observations	1,958	2,295	2,421	2,664	2,310	2,657	2,771	2,843
Countries	10	10	11	12	10	12	12	12
Towns	178	209	220	241	210	240	248	254
Share treated	.478	.45	.445	.452	.462	.446	.44	.433
Adjusted R^2	0.946	0.942	0.941	0.937	0.942	0.936	0.933	0.930

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.12: Measurement: missing NTL year imputation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Imputed years:	0	1	2	3	4	0	1	2	3	4
Connection × access	0.101**	0.0971**	0.0940**	0.0940**	0.0917**	0.109***	0.0853**	0.0861*	0.0822*	0.0822*
	(0.0448)	(0.0449)	(0.0443)	(0.0443)	(0.0439)	(0.0383)	(0.0410)	(0.0440)	(0.0440)	(0.0440)
Town FE	×	×	×	×	×	×	×	×	×	×
Country × year FE	×	×	×	×	×	×	×	×	×	×
GSM coverage	×	×	×	×	×	×	×	×	×	×
Geography controls × connection	×	×	×	×	×	×	×	×	×	×
NTL in early years						×	×	×	×	×
Observations	1,958	2,013	2,024	2,024	2,035	2,310	2,640	2,706	2,717	2,717
Countries	10	10	10	10	10	10	12	12	12	12
Towns	178	183	184	184	185	210	240	246	247	247
Share treated	.478	.464	.462	.462	.459	.462	.45	.451	.449	.449
Adjusted R^2	0.946	0.947	0.947	0.947	0.947	0.942	0.937	0.935	0.935	0.935

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.13: Robustness: electricity

Sample:	extended		capital and landing		all nodal	
Dep. var.: electricity access	(1)	(2)	(3)	(4)	(5)	(6)
Connection × access	0.000387	-0.0359	0.0411	0.0579	-0.0731	-0.0914
	(0.103)	(0.0688)	(0.114)	(0.0766)	(0.211)	(0.173)
Town FE	×	×	×	×	×	×
Country × year FE	×	×	×	×	×	×
GSM coverage	×	×	×	×	×	×
Geography controls × connection	×	×	×	×	×	×
Weights		×		×		×
Observations	270	270	250	250	102	102
Countries	6	6	6	6	4	4
Towns	94	94	88	88	37	37
Share treated	.351	.351	.307	.307	.351	.351
Adjusted R^2	0.680	0.806	0.675	0.784	0.720	0.814

Notes: Access to the electricity grid is aggregated at the town level. Weighting by the number of households. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Afrobarometer (rounds 1-4), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.14: Robustness: alternative clustering

			grid cell	
	(1)	(2)	(3)	(4)
SE cluster:	AP	state	1°	3°
Connection × access	0.109***	0.109***	0.109***	0.109***
	(0.0383)	(0.0384)	(0.0376)	(0.0388)
Town FE	×	×	×	×
Country × year FE	×	×	×	×
GSM coverage	×	×	×	×
Geography controls × connection	×	×	×	×
Clusters	159	69	106	52
Observations	2,310	2,310	2,310	2,310
Countries	10	10	10	10
Towns	210	210	210	210
Share treated	.462	.462	.462	.462
Adjusted R^2	0.942	0.942	0.942	0.942

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.15: Population growth

Dep. var.: population	(1)	(2)	(3)	(4)	(5)
Time window:	baseline	2000 - (SMC + 3)	incl. 1995	excl. 1995	pre/post
Connection × access	0.0116	-0.00283	0.0218	0.0124	0.0102
	(0.0183)	(0.00805)	(0.0374)	(0.0277)	(0.0191)
Town FE	×	×	×	×	×
Country × year FE	×	×	×	×	×
GSM coverage	×	×	×	×	×
Geography controls × connection	×	×	×	×	×
Observations	2,310	1,765	830	610	440
Countries	10	10	10	10	10
Towns	210	210	210	210	210
Share treated	*.462*	*.462*	*.462*	*.462*	*.462*
Adjusted R^2	0.999	1.000	0.997	0.999	1.000

Notes: Population is measured as the logarithmic sum of pixel-level population counts. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Gridded Population of the World, Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.16: Robustness: absolute population thresholds

	(1)	(2)	(3)	(4)	(5)
Threshold:	30,000	40,000	50,000	75,000	100,000
Connection × access	0.129***	0.119***	0.109***	0.102***	0.0940***
	(0.0418)	(0.0391)	(0.0383)	(0.0346)	(0.0347)
Town FE	×	×	×	×	×
Country × year FE	×	×	×	×	×
GSM coverage	×	×	×	×	×
Geography controls × connection	×	×	×	×	×
Observations	1,903	2,167	2,310	2,453	2,486
Countries	10	10	10	10	10
Towns	173	197	210	223	226
Share treated	.462	.452	.462	.471	.478
Adjusted R^2	0.929	0.938	0.942	0.947	0.950

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.17: Robustness: percentile population thresholds

	(1)	(2)	(3)	(4)	(5)	(6)
Threshold:	100%	90%	80%	70%	60%	50%
Connection × access	0.0908***	0.115***	0.154***	0.168***	0.158***	0.136**
	(0.0335)	(0.0379)	(0.0480)	(0.0547)	(0.0577)	(0.0646)
Town FE	×	×	×	×	×	×
Country × year FE	×	×	×	×	×	×
GSM coverage	×	×	×	×	×	×
Geography controls × connection	×	×	×	×	×	×
Observations	2,640	2,145	1,659	1,298	1,074	854
Countries	10	10	9	9	9	9
Towns	240	195	151	118	98	77
Share treated	.5	.477	.49	.508	.531	.532
Adjusted R^2	0.963	0.948	0.943	0.939	0.939	0.940

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.18: Robustness: industry heterogeneity

	agriculture		manufacturing		services	
	(1)	(2)	(3)	(4)	(5)	(6)
Connection × access	-0.0188	-0.0194	0.0133*	0.0129*	0.00547	0.00642
	(0.0161)	(0.0163)	(0.00756)	(0.00739)	(0.0104)	(0.0107)
Town FE	×	×	×	×	×	×
Country × year FE	×	×	×	×	×	×
GSM coverage	×	×	×	×	×	×
Geography controls × connection		×		×		×
Observations	956,454	956,454	956,454	956,454	956,454	956,454
Countries	5	5	5	5	5	5
Regions	99	99	99	99	99	99
Share treated	.208	.208	.208	.208	.208	.208
Adjusted R^2	0.127	0.128	0.035	0.039	0.094	0.100

Notes: Employment shares are measured at the region level. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, IPUMS International, Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.19: Robustness: access point

	(1)	(2)
Connection × access point ∈ (0km, 10km]	0.147***	0.119***
	(0.0511)	(0.0385)
Connection × access point ∈ (10km, 30km]	0.0925	0.0863**
	(0.0606)	(0.0367)
Connection × access point ∈ (30km, 50km]	0.0489	0.0280
	(0.0545)	(0.0369)
Town FE	×	×
Country × year FE	×	×
GSM coverage	×	×
Geography controls × connection	×	×
Untreated controls		×
Observations	2,310	4,114
Countries	10	12
Towns	210	374
Share treated	.462	.27
Adjusted R^2	0.942	0.927

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.20: Robustness: distance threshold access points

Threshold:	(1) 5km	(2) 7.5km	(3) 10km	(4) 12.5km	(5) 15km
Connection × access	0.0952**	0.107**	0.109***	0.0870**	0.0868**
	(0.0372)	(0.0426)	(0.0383)	(0.0410)	(0.0400)
Town FE	×	×	×	×	×
Country × year FE	×	×	×	×	×
GSM coverage	×	×	×	×	×
Geography controls × connection	×	×	×	×	×
Observations	1,936	2,156	2,310	2,387	2,398
Countries	9	10	10	10	10
Towns	176	196	210	217	218
Share treated	.415	.423	.462	.498	.518
Adjusted R^2	0.945	0.940	0.942	0.942	0.941

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Table B.21: Robustness: control group

	access point prior to				post-SMC years		
	(1) 2020	(2) 2018	(3) 2016	(4) 2014	(5) 20	(6) 14	(7) 8
Connection × access	0.109**	0.0879*	0.150**	0.146**	0.109**	0.0613	0.122**
	(0.0453)	(0.0503)	(0.0577)	(0.0647)	(0.0453)	(0.0487)	(0.0558)
Town FE	×	×	×	×	×	×	×
Country × year FE	×	×	×	×	×	×	×
GSM coverage	×	×	×	×	×	×	×
Geography controls × connection	×	×	×	×	×	×	×
Observations	2,310	2,101	1,496	1,177	2,310	2,079	1,320
Countries	10	9	8	6	10	10	8
Towns	210	191	136	107	210	189	120
Share treated	.459	.492	.522	.467	.459	.439	.592
Adjusted R^2	0.948	0.948	0.956	0.960	0.948	0.953	0.956

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

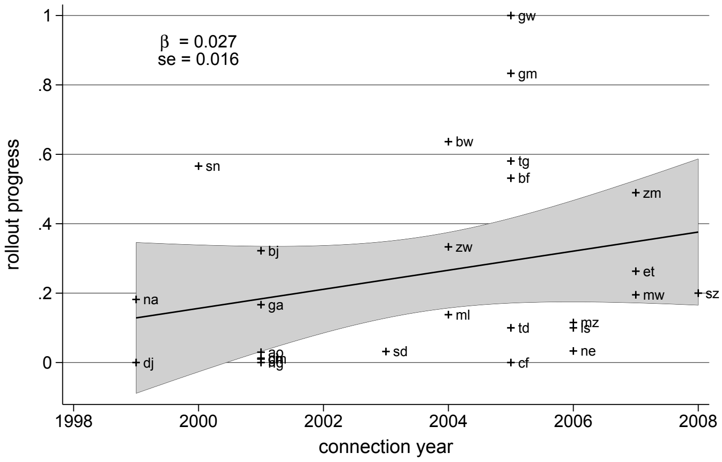
Table B.22: Robustness: lagged mobile coverage

	(1)	(2)	(3)	(4)	(5)	(6)
Connection × access	0.109***	0.110***	0.105***	0.106***	0.105***	0.102***
	(0.0383)	(0.0378)	(0.0384)	(0.0373)	(0.0373)	(0.0381)
GSM coverage	0.0539					
	(0.0380)					
GSM coverage (lag 1)		0.0758*				
		(0.0402)				
GSM coverage (lag 2)			-0.0161			
			(0.0399)			
GSM coverage (lag 3)				0.0510		
				(0.0327)		
GSM coverage (lag 4)					0.0518*	
					(0.0311)	
GSM coverage (lag 5)						0.0434
						(0.0335)
Town FE	×	×	×	×	×	×
Country × year FE	×	×	×	×	×	×
Geography controls × connection	×	×	×	×	×	×
Observations	2,310	2,310	2,310	2,310	2,310	2,310
Countries	10	10	10	10	10	10
Towns	210	210	210	210	210	210
Share treated	.462	.462	.462	.462	.462	.462
Adjusted R^2	0.942	0.942	0.942	0.942	0.942	0.942

Notes: NTL light intensity is measured as the logarithmic sum of light intensities. Geography controls include indicators for local availability of and (logarithmic) distance to the capital, road, railroad, and port. Geography controls are constant over time and enter the model as interaction with the connection indicator. Robust standard errors clustered at the level of the closest access point are reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2020), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

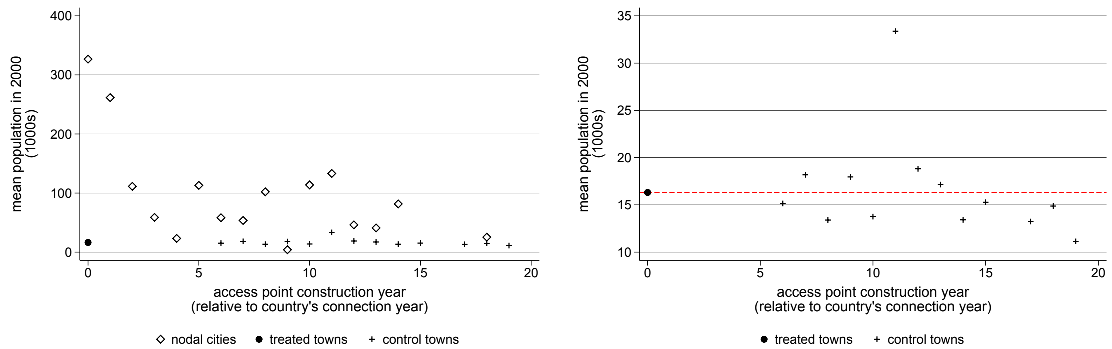
C Figures

Figure C.1: SMC connection and national backbone rollout



Note: Figure plots rollout progress at the time of connection against connection year. Rollout progress is measured as share of access points in the connection year relative to the total number of access points in the most recent data year, 2020. Marker labels are ISO-2 country codes. Black line shows linear fit. The gray area represents 95% confidence intervals. β and 'se' refer to slope coefficient and standard error, respectively. *Sources:* Africa Bandwidth Maps, Submarine Cable Map.

Figure C.2: National backbone rollout



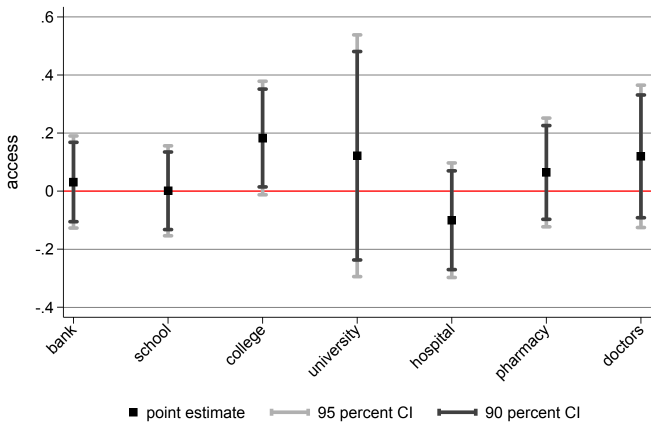
(a) with nodal cities **(b)** treatment and control towns

Note: The figure depicts the average population size of connected cities and towns by year relative to the connection year. On the left, the black dot in the lower left corner represents the treated towns, while the control towns are represented by the plus symbol and the nodal cities by a diamond. For treated towns and nodal cities that were connected in earlier years than the arrival of an SMC are shown in year zero as well for clarity. On the right, the treatment and control group are shown in more detail without nodal cities. *Sources:* Africa Bandwidth Maps, Africapolis, own calculations.

Figure C.3: Internet cafe in rural South Africa, 2009

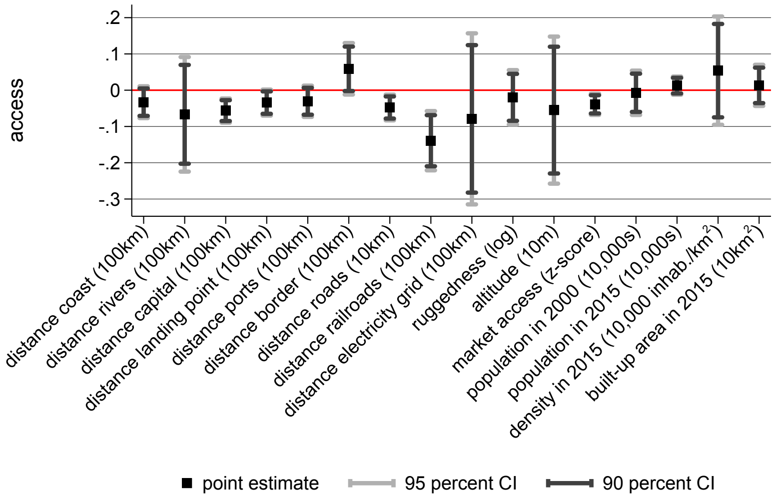
Source: Ossewa [CC BY-SA 4.0].

Figure C.4: Sample balance: POIs



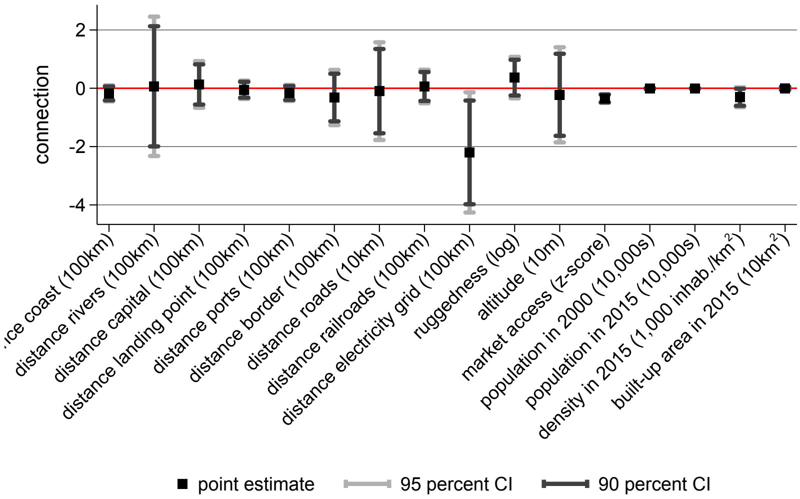
Note: Figure plots point estimates and confidence intervals for linear regressions of various points-of-interest on treatment group status. *Sources:* Africa Bandwidth Maps, Africapolis, Open Street Map, own calculations.

Figure C.5: Sample balance: national backbone rollout and geography



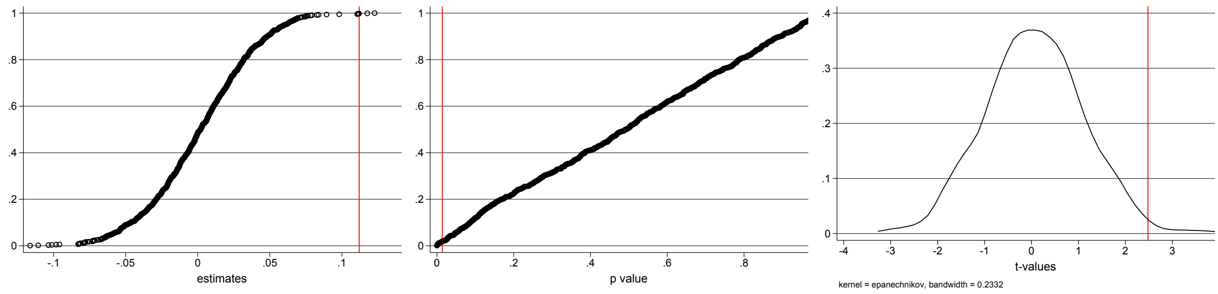
Note: Figure plots point estimates and confidence intervals for linear regressions of geodesic distance to various points-of-interest on treatment group status. *Sources:* Africa Bandwidth Maps, Africapolis, Open Street Map, own calculations.

Figure C.6: Sample balance: SMC connection and geography



Note: Figure plots point estimates and confidence intervals for linear regressions of geodesic distance to various points-of-interest on connection year, controlling for coastal country status. *Sources:* Africa Bandwidth Maps, Africapolis, Open Street Map, own calculations.

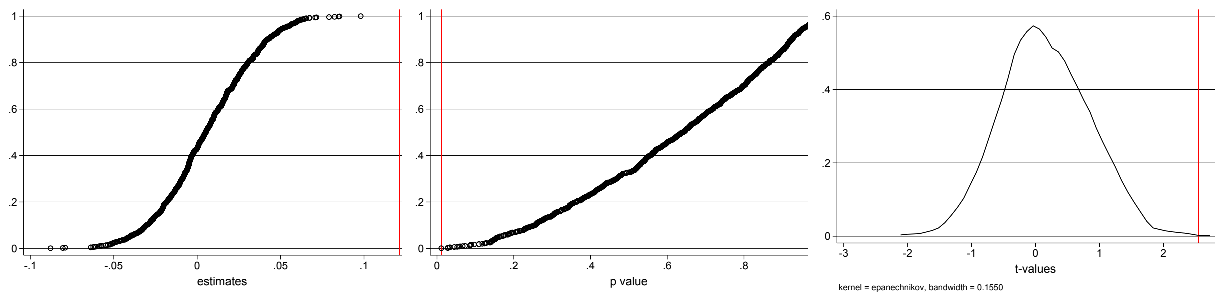
Figure C.7: Robustness: access placebo



(a) estimates **(b)** p-values **(c)** t-values

Note: Figure depicts different statistics of 1,000 permutations for our baseline estimation with randomly assigned treatment group status. Panel (a) plots coefficient estimates for our main effect and Panel (b) the respective p-values. Panel (c) depicts the kernel density estimate for the distribution of t-statistics. Values from the true regression are shown as vertical red lines. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2017), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

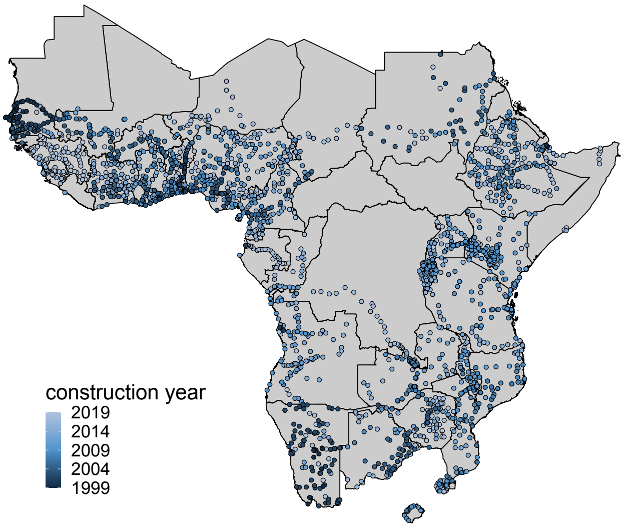
Figure C.8: Robustness: connection placebo



(a) estimates **(b)** p-values **(c)** t-values

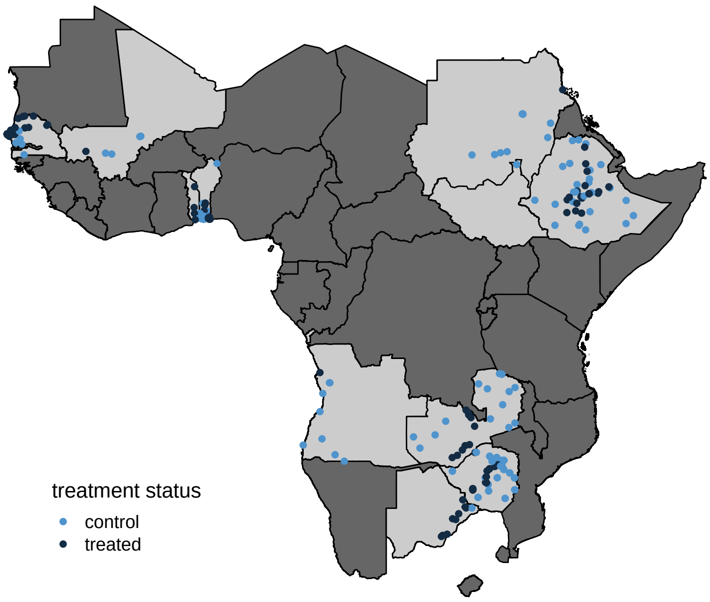
Note: Figure depicts different statistics of 1,000 permutations for our baseline estimation with randomly assigned treatment group status. Panel (a) plots coefficient estimates for our main effect and Panel (b) the respective p-values. Panel (c) depicts the kernel density estimate for the distribution of t-statistics. Values from the true regression are shown as vertical red lines. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2017), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Figure C.9: Access points



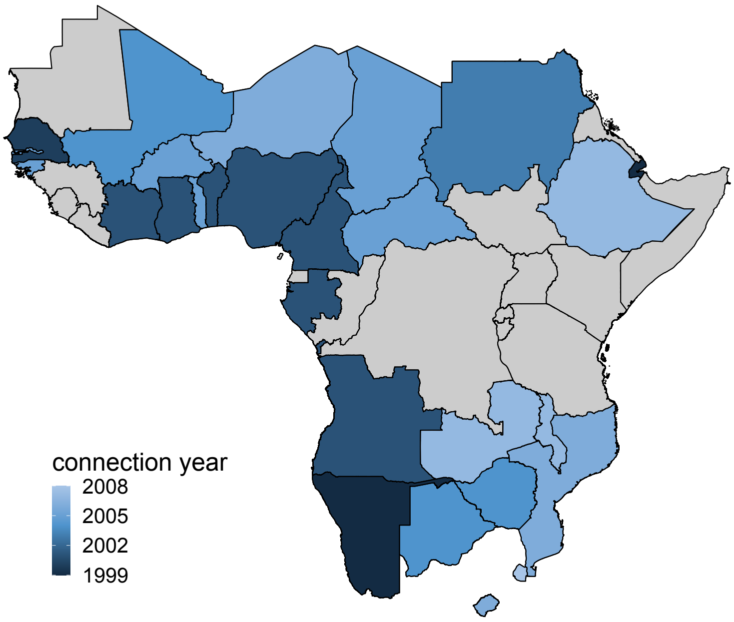
Note: Figure maps the location of all SSA access points. Blue coloring indicates contruction years with brighter blue corresponding to later years. *Sources:* Africa Bandwidth Maps, Table D.23.

Figure C.10: Sample: treatment and control towns



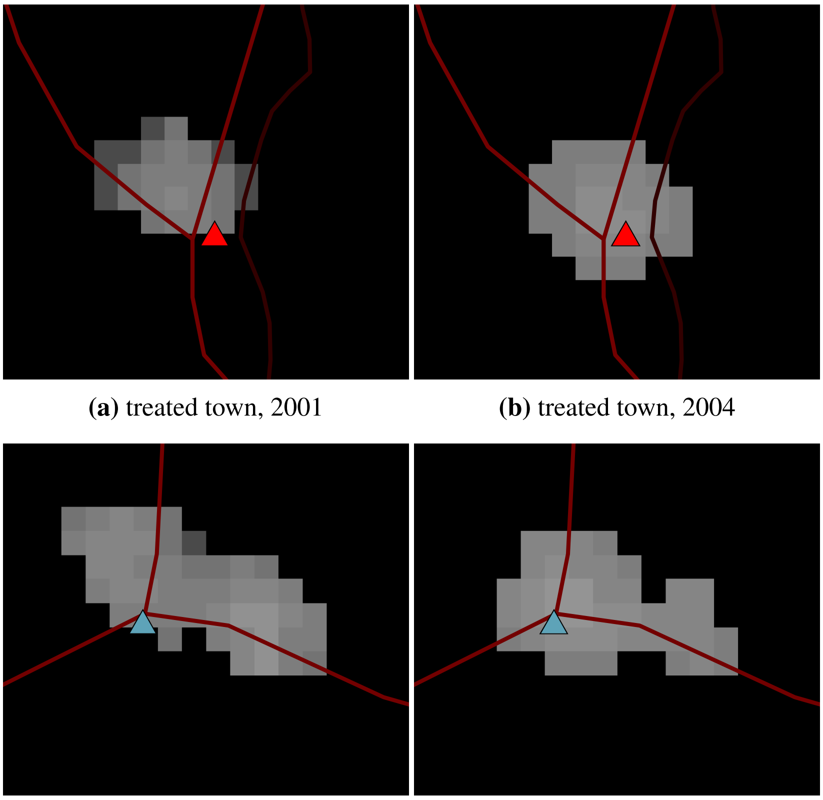
Note: Figure maps the countries in our main sample (brighter gray) and for each country the towns in the treatment and control group. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Africapolis, own calculations.

Figure C.11: SMC connection years



Note: Figure maps SSA countries and their country-wide connection years, with darker blues indicating earlier connection years. *Sources:* Submarine Cable Map.

Figure C.12: Data example treatment and control town, Benin

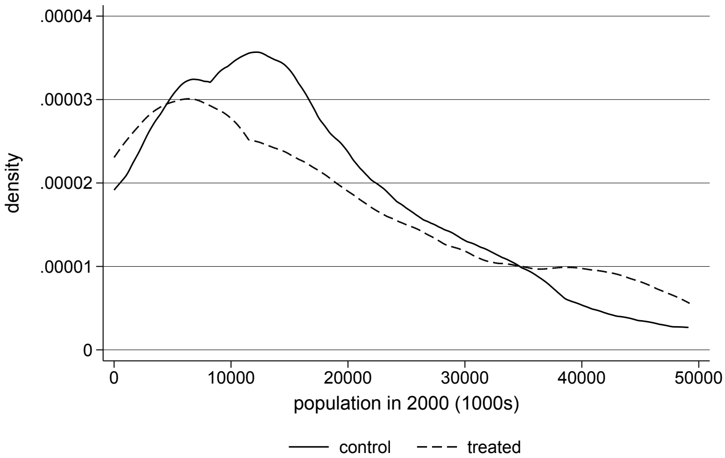


(a) treated town, 2001 **(b)** treated town, 2004

(c) control town, 2001 **(d)** control town, 2004

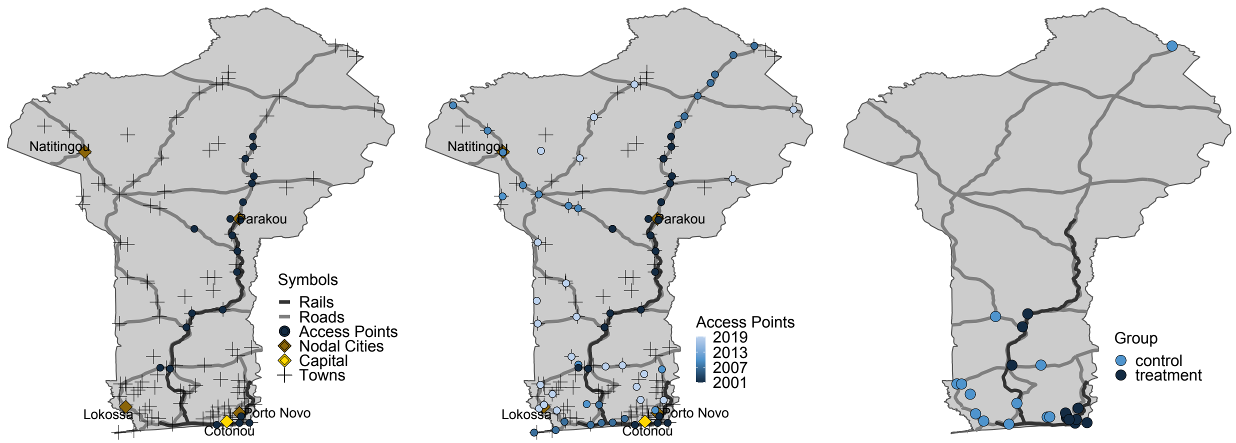
Note: The panels show a treatment and control group town from Benin, with gray NTLs pixels from 2001 and 2004. Access points are marked with a triangle (red if constructed until 2001 and blue if constructed afterward). The dark red line represents a major road connecting and the darker red line the railway. The black-to-white scale indicates light intensity, with brighter colors reflecting higher light intensities. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2017), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Figure C.13: Population distribution



Note: Figure plots kernel density estimates for the distribution of population size in 2000, separately for treated and control group towns. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Africapolis, own calculations.

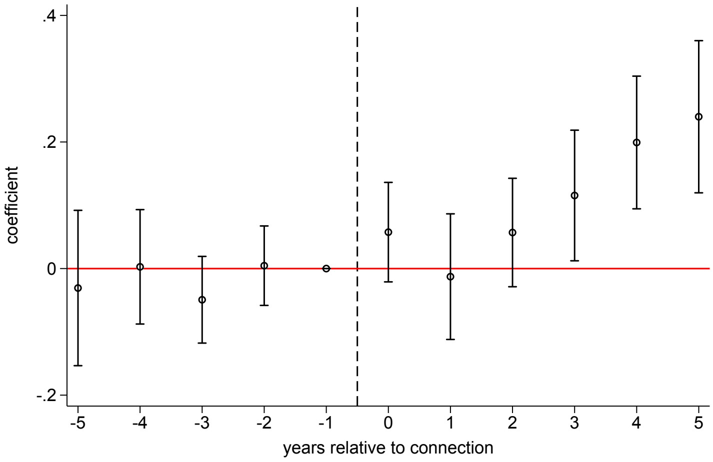
Figure C.14: Data example: national rollout in Benin



(a) Access points, 2001 **(b)** All access points **(c)** Treatment/control group

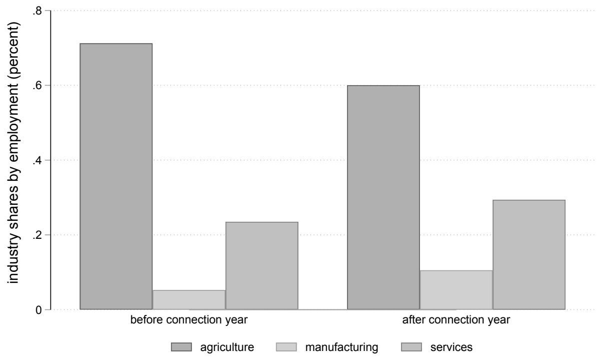
Note: Figure outlines the rollout of access points in Benin. Besides access points, the maps include the capital city, nodal cities, and all towns. Railroads and roads are included as well. In the left panel, the early rollout with access points being constructed until the arrival of the SMC in 2001 is shown. The middle panel depicts further access points and their respective construction years. The right panel shows the towns of your analysis divided into treatment and control group. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2017), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Figure C.15: Event-study coefficients with 90%-level CIs)

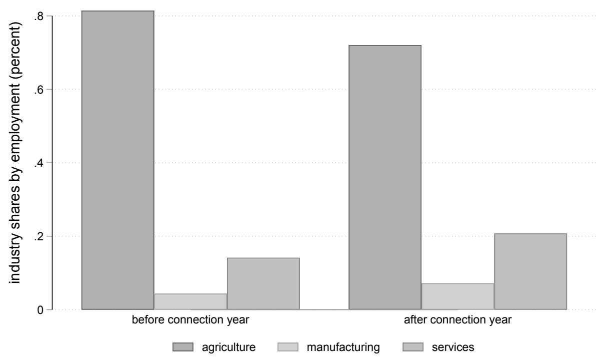


Note: The figure plots event study coefficients μ_{1j} based on Equation 2. The outcome is the logarithmic sum of light intensities. Bars represent 90% confidence intervals using robust standard errors clustered at the level of the closest access point. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, Li et al. (2017), Africapolis, Collins Bartholomew Mobile Coverage Maps, Open Street Map, own calculations.

Figure C.16: Regional industry shares



(a) treatment regions



(b) control regions

Note: Figure plots regional employment shares by industry for treated (Panel (a)) and control regions (Panel (b)), prior and after connection year. *Sources:* Africa Bandwidth Maps, Submarine Cable Map, IPUMS International, Africapolis, own calculations.

Figure C.17: Ethnic diversity

Note: Figure depicts the number of ethnic groups whose majority regions received at least one access point prior to the country-wide connection year. Brighter blues indicate a higher number of initially connected ethnic groups. *Sources:* Weidmann et al. (2010), Africa Bandwidth Maps, Submarine Cable Map, Africapolis, own calculations.

D Early backbone deployment projects

Table D.23: Source register backbone deployment, pre-2009

Country	city/town	connection	URL source
Angola	Benguela	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	Cabinda	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	Dondo	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	N'dalatando	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	Sumbe	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	Chibia	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	Lubango	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	Luanda	2001	https://www.submarinenetworks.com/en/systems/euro-africa/sat-3
Angola	Malanje	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	Moçâmedes	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	Tômbua	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	N'zeto	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Benin	Kandi	2007	http://www.infodev.org/infodev-files/resource/InfodevDocuments_421.pdf
Benin	Natitingou	2009	http://www.absucep.bj/fichiers/telechargeables/rapportFinal_SU_Volume1.pdf
Benin	Ouidah	2007	https://www.commsupdate.com/articles/2007/09/20/benin-and-togo-switch-on-sat-3-link/
Benin	Parakou	2001	https://researchictafrica.net/publications/Telecommunications_Sector_Performance_Reviews_2007/Benin%20Telecommunications%20Sector%20Per-formance%20Review%202007%20-%20English.pdf
Benin	Djougou	2009	http://www.absucep.bj/fichiers/telechargeables/rapportFinal_SU_Volume1.pdf
Benin	Cotonou	2001	https://www.submarinenetworks.com/en/systems/euro-africa/sat-3
Benin	Porto-Novo	2001	https://researchictafrica.net/publications/Telecommunications_Sector_Performance_Reviews_2007/Benin%20Telecommunications%20Sector%20Per-formance%20Review%202007%20-%20English.pdf
Benin	Abomey	2001	http://www.infodev.org/infodev-files/resource/InfodevDocuments_386.pdf
Botswana	Mahalapye	2004	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
Botswana	Palapye	2004	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
Botswana	Serowe	2005	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
Botswana	Nata	2008	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
Botswana	Ghanzi	2008	https://www.balancingact-africa.com/news/telecoms_en/4700/btc-launch-us323-million-trans-kalahari-fibre-project-in-botswana
Botswana	Mamuno	2008	https://www.balancingact-africa.com/news/telecoms_en/4700/btc-launch-us323-million-trans-kalahari-fibre-project-in-botswana
Botswana	Mochudi	2004	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
Botswana	Molepolole	2004	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
Botswana	Francistown	2004	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
Botswana	Maun	2008	https://www.balancingact-africa.com/news/telecoms_en/4700/btc-launch-us323-million-trans-kalahari-fibre-project-in-botswana
Botswana	Kasane	2008	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
Botswana	Ngoma	2008	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
Botswana	Gaborone	2004	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
Botswana	Lobatse	2004	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
Botswana	Kanye	2004	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
Botswana	Jwaneng	2005	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
Burkina Faso	Banfora	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Ouagadougou	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Tenkodogo	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Koupéla	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Koudougou	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Fada N'Gourma	2009	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Bobo Dioulasso	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Orodara	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Zorgho	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Cameroon	Meiganga	2005	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Cameroon	Bafia	2009	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Cameroon	Yaounde	2005	https://www.researchictafrica.net/countries/cameroon/Sector_Strategy_for_Telecommunications_and_ICT_2005-2015.pdf
Cameroon	Mbalmayo	2009	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Cameroon	Bélabo	2005	https://www.researchictafrica.net/countries/cameroon/Sector_Strategy_for_Telecommunications_and_ICT_2005-2015.pdf
Cameroon	Edéa	2005	https://www.researchictafrica.net/countries/cameroon/Sector_Strategy_for_Telecommunications_and_ICT_2005-2015.pdf
Cameroon	Douala	2001	https://www.submarinenetworks.com/en/systems/euro-africa/sat-3
Cameroon	Bamenda	2009	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html

Table continues on the next page.

Country	city/town	connection	URL source
Cameroon	Kribi	2005	https://www.researchictafrica.net/countries/cameroon/Sector_Strategy_for_Telecommunications_and_ICT_2005-2015.pdf
Cameroon	Limbe	2009	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Cameroon	Bafang	2009	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Cameroon	Bafoussam	2009	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Chad	Doba	2005	https://www.researchictafrica.net/countries/cameroon/Sector_Strategy_for_Telecommunications_and_ICT_2005-2015.pdf
Chad	Ndjamena	2009	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Côte d'Ivoire	San-Pedro	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Sassandra	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27296
Côte d'Ivoire	Soubré	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Aboisso	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Gagnoa	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Divo	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Toumodi	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27296
Côte d'Ivoire	Yamoussoukro	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Dimbokro	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Abidjan	2001	https://www.submarinenetworks.com/en/systems/euro-africa/sat-3
Côte d'Ivoire	Man	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Guiglo	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Daloa	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Bouaflé	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Ferkessédougou	2008	http://malijet.com/a_la_une_du_mali/7721-mali-c_te_d_ivoire_interconnexion_de_la_fibre_optique.html
Côte d'Ivoire	Bouaké	2008	http://malijet.com/a_la_une_du_mali/7721-mali-c_te_d_ivoire_interconnexion_de_la_fibre_optique.html
Djibouti	Ali Sabieh	2007	https://www.submarinenetworks.com/en/systems/eurasia-terrestrial/renovation-of-the-djibouti-ethiopia-digital-corridor
Djibouti	Galafi	2007	https://www.submarinenetworks.com/en/systems/eurasia-terrestrial/renovation-of-the-djibouti-ethiopia-digital-corridor
Djibouti	Djibouti	1999	https://web.archive.org/web/20081222095315/http://www.heise.de/tp/r4/artikel/5/5245/1.html
Eritrea	Mendefera	2009	https://en.wikipedia.org/wiki/EASSy
Eritrea	Asmara	2009	https://en.wikipedia.org/wiki/EASSy
Eritrea	Massawa	2009	https://en.wikipedia.org/wiki/EASSy
Ethiopia	Addis Ababa	2007	https://www.lightwaveonline.com/network-design/article/16663413/zte-to-build-national-network-in-ethiopia
Ethiopia	Debre Birhan	2007	https://www.flickr.com/photos/ssong/7013508301/
Ethiopia	Debre Markos	2007	https://www.flickr.com/photos/ssong/7013508301/
Ethiopia	Dese	2007	https://www.lightwaveonline.com/network-design/article/16663413/zte-to-build-national-network-in-ethiopia
Ethiopia	Bahir Dar	2007	https://www.lightwaveonline.com/network-design/article/16663413/zte-to-build-national-network-in-ethiopia
Ethiopia	Gondar	2007	https://www.lightwaveonline.com/network-design/article/16663413/zte-to-build-national-network-in-ethiopia
Ethiopia	Asosa	2009	https://www.zte.com.cn/global/about/magazine/zte-technologies/2009/6/en_414/172517.html
Ethiopia	Dire Dawa	2007	https://www.lightwaveonline.com/network-design/article/16663413/zte-to-build-national-network-in-ethiopia
Ethiopia	Harar	2007	https://www.lightwaveonline.com/network-design/article/16663413/zte-to-build-national-network-in-ethiopia
Ethiopia	Asela	2009	https://www.zte.com.cn/global/about/magazine/zte-technologies/2009/6/en_414/172517.html
Ethiopia	Nazret	2007	https://www.lightwaveonline.com/network-design/article/16663413/zte-to-build-national-network-in-ethiopia
Ethiopia	Debre Zeyit	2007	https://www.lightwaveonline.com/network-design/article/16663413/zte-to-build-national-network-in-ethiopia
Ethiopia	Nekemte	2009	https://www.zte.com.cn/global/about/magazine/zte-technologies/2009/6/en_414/172517.html
Ethiopia	Gore	2009	https://www.zte.com.cn/global/about/magazine/zte-technologies/2009/6/en_414/172517.html
Ethiopia	Jima	2007	https://www.lightwaveonline.com/network-design/article/16663413/zte-to-build-national-network-in-ethiopia
Ethiopia	Shashemene	2007	https://www.lightwaveonline.com/network-design/article/16663413/zte-to-build-national-network-in-ethiopia
Ethiopia	Hagere Hiywet	2009	https://www.zte.com.cn/global/about/magazine/zte-technologies/2009/6/en_414/172517.html
Ethiopia	Gimbi	2009	https://www.zte.com.cn/global/about/magazine/zte-technologies/2009/6/en_414/172517.html
Ethiopia	Arba Minch	2009	https://www.zte.com.cn/global/about/magazine/zte-technologies/2009/6/en_414/172517.html
Ethiopia	Hosaina	2009	https://www.zte.com.cn/global/about/magazine/zte-technologies/2009/6/en_414/172517.html
Ethiopia	Awasa	2007	https://www.lightwaveonline.com/network-design/article/16663413/zte-to-build-national-network-in-ethiopia
Ethiopia	Sodo	2007	https://www.lightwaveonline.com/network-design/article/16663413/zte-to-build-national-network-in-ethiopia
Ethiopia	Jijiga	2007	https://www.lightwaveonline.com/network-design/article/16663413/zte-to-build-national-network-in-ethiopia
Ethiopia	Aksum	2009	https://www.zte.com.cn/global/about/magazine/zte-technologies/2009/6/en_414/172517.html
Ethiopia	Adigrat	2009	https://www.zte.com.cn/global/about/magazine/zte-technologies/2009/6/en_414/172517.html
Ethiopia	Mekele	2007	https://www.lightwaveonline.com/network-design/article/16663413/zte-to-build-national-network-in-ethiopia
Gabon	Libreville	2001	https://www.submarinenetworks.com/en/systems/euro-africa/sat-3

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Country	city/town	connection	URL source
Gambia	Banjul	2005	https://www.siemens.be/cmc/newsletters/index.aspx?id=13-574-16687
Gambia	Brikama	2005	https://www.siemens.be/cmc/newsletters/index.aspx?id=13-574-16687
Gambia	Basse Santa Su	2005	https://www.siemens.be/cmc/newsletters/index.aspx?id=13-574-16687
Gambia	Bansang	2005	https://www.siemens.be/cmc/newsletters/index.aspx?id=13-574-16688
Gambia	Georgetown	2005	https://www.siemens.be/cmc/newsletters/index.aspx?id=13-574-16689
Ghana	Kumasi	2004	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.195.150&rep=rep1&type=pdf
Ghana	Obuasi	2004	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.195.150&rep=rep1&type=pdf
Ghana	Sunyani	2007	https://wikileaks.org/plusd/cables/07ACCRA2162_a.html
Ghana	Cape Coast	2004	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.195.150&rep=rep1&type=pdf
Ghana	Winneba	2004	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.195.150&rep=rep1&type=pdf
Ghana	Koforidua	2004	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.195.150&rep=rep1&type=pdf
Ghana	Nkawkaw	2004	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.195.150&rep=rep1&type=pdf
Ghana	Accra	2001	https://www.submarinenetworks.com/en/systems/euro-africa/sat-3
Ghana	Tema	2004	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.195.150&rep=rep1&type=pdf
Ghana	Tamale	2007	https://wikileaks.org/plusd/cables/07ACCRA2162_a.html
Ghana	Ho	2008	https://www.moc.gov.gh/eastern-corridor-fiber-optic-backbone
Ghana	Sekondi	2004	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.195.150&rep=rep1&type=pdf
Guinea-Bissau	Bissau	2005	https://www.siemens.be/cmc/newsletters/index.aspx?id=13-574-16687
Kenya	Bungoma	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Embu	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Garissa	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Kakamega	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Thika	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Kisumu	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Mwingi	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Nanyuki	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Machakos	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Meru	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Mombasa	2009	https://phys.org/news/2009-06-kenya-undersea-broadband-fibre-optic.html
Kenya	Nairobi	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Naivasha	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Nakuru	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Nyeri	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Voi	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Kenya	Eldoret	2009	https://www.nation.co.ke/kenya/business/teams-begins-laying-fibre-optic-cables-588868
Lesotho	Teyateyaneng	2009	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Lesotho.pdf
Lesotho	Butha-Buthe	2009	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Lesotho.pdf
Lesotho	Hlotse	2009	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Lesotho.pdf
Lesotho	Mafetang	2009	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Lesotho.pdf
Lesotho	Maseru	2006	https://researchictafrica.net/wp/wp-content/uploads/2018/01/2017_The-State-of-ICT-in-Lesotho_RIA_LCA.pdf
Lesotho	Mohales Hoek	2009	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Lesotho.pdf
Lesotho	Mokhotlong	2009	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Lesotho.pdf
Lesotho	Moyeni	2009	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Lesotho.pdf
Madagascar	Antananarivo	2009	https://www.lightwaveonline.com/network-design/article/16667160/orange-inaugurates-lion-submarine-cable-in-reunion
Madagascar	Toamasina	2009	https://www.lightwaveonline.com/network-design/article/16667160/orange-inaugurates-lion-submarine-cable-in-reunion
Madagascar	Mahajanga	2009	https://www.lightwaveonline.com/network-design/article/16667160/orange-inaugurates-lion-submarine-cable-in-reunion
Madagascar	Marovoay	2009	https://www.lightwaveonline.com/network-design/article/16667160/orange-inaugurates-lion-submarine-cable-in-reunion
Madagascar	Fianarantsoa	2009	https://www.lightwaveonline.com/network-design/article/16667160/orange-inaugurates-lion-submarine-cable-in-reunion
Madagascar	Ihosy	2009	https://www.lightwaveonline.com/network-design/article/16667160/orange-inaugurates-lion-submarine-cable-in-reunion
Madagascar	Antsirabe	2009	https://www.lightwaveonline.com/network-design/article/16667160/orange-inaugurates-lion-submarine-cable-in-reunion
Malawi	Lilongwe	2007	https://www.commsupdate.com/articles/2007/06/27/electric-board-begins-installing-fibre/
Malawi	Blantyre	2007	https://www.commsupdate.com/articles/2007/06/27/electric-board-begins-installing-fibre/
Malawi	Mwanza	2007	https://www.commsupdate.com/articles/2007/07/16/mtl-connects-network-to-mozambique/
Mali	Bamako	2004	https://journals.openedition.org/cea/944#ftn5
Mali	Bafoulabé	2004	https://journals.openedition.org/cea/944#ftn5

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Country	city/town	connection	URL source
Mali	Kayes	2004	https://journals.openedition.org/cea/944#ftn5
Mali	Kita	2004	https://journals.openedition.org/cea/944#ftn5
Mali	Yélimané	2007	https://www.amrtp.ml/pdf/rapport_act/Rapport_2007.pdf
Mali	Kati	2004	https://journals.openedition.org/cea/944#ftn5
Mali	Koulikoro	2009	https://www.flickr.com/photos/ssong/6092447867/
Mali	Mopti	2009	https://www.afribone.com/?Inauguration-de-la-fibre-optique
Mali	Ségou	2009	https://www.flickr.com/photos/ssong/6092447867/
Mali	Bougouni	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Mali	Koutiala	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Mali	Sikasso	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Mozambique	Pemba	2008	https://macauhub.com.mo/2009/05/07/7018/
Mozambique	Xai-Xai	2006	https://www.fomsn.com/networks/fiber/fiber-optic-network-links-mozambique-and-south-africa/
Mozambique	Inhambane	2006	https://www.fomsn.com/networks/fiber/fiber-optic-network-links-mozambique-and-south-africa/
Mozambique	Maxixe	2009	https://farm7.static.flickr.com/6150/6035058808_7dc34bcf27_b.jpg
Mozambique	Vilanculos	2006	https://www.fomsn.com/networks/fiber/fiber-optic-network-links-mozambique-and-south-africa/
Mozambique	Chimoio	2008	https://macauhub.com.mo/2009/05/07/7018/
Mozambique	Manica	2009	https://farm7.static.flickr.com/6150/6035058808_7dc34bcf27_b.jpg
Mozambique	Maputo	2006	https://www.fomsn.com/networks/fiber/fiber-optic-network-links-mozambique-and-south-africa/
Mozambique	Nampula	2007	https://macauhub.com.mo/2009/05/07/7018/
Mozambique	Nacala	2009	https://farm7.static.flickr.com/6150/6035058808_7dc34bcf27_b.jpg
Mozambique	Lichinga	2008	https://macauhub.com.mo/2009/05/07/7018/
Mozambique	Cuamba	2007	https://macauhub.com.mo/2009/05/07/7018/
Mozambique	Beira	2006	https://www.fomsn.com/networks/fiber/fiber-optic-network-links-mozambique-and-south-africa/
Mozambique	Dondo	2007	https://www.commsupdate.com/articles/2007/07/09/tdm-lights-latest-link/
Mozambique	Tete	2008	https://macauhub.com.mo/2009/05/07/7018/
Mozambique	Nicuadala	2007	https://www.commsupdate.com/articles/2007/07/09/tdm-lights-latest-link/
Mozambique	Quelimane	2007	https://www.commsupdate.com/articles/2007/07/09/tdm-lights-latest-link/
Namibia	Karibib	2002	https://epublications.uef.fi/pub/URN_NBN_fi_joy-20090045/URN_NBN_fi_joy-20090045.pdf
Namibia	Omaruru	2002	https://epublications.uef.fi/pub/URN_NBN_fi_joy-20090045/URN_NBN_fi_joy-20090045.pdf
Namibia	Swakopmund	2002	https://epublications.uef.fi/pub/URN_NBN_fi_joy-20090045/URN_NBN_fi_joy-20090045.pdf
Namibia	Walvis Bay	2002	http://home.intekom.com/intekom/clients/t/telecom_namibia/technology.stm
Namibia	Maltahöhe	2002	https://epublications.uef.fi/pub/URN_NBN_fi_joy-20090045/URN_NBN_fi_joy-20090045.pdf
Namibia	Mariental	1999	https://epublications.uef.fi/pub/URN_NBN_fi_joy-20090045/URN_NBN_fi_joy-20090045.pdf
Namibia	Rehoboth	1999	https://epublications.uef.fi/pub/URN_NBN_fi_joy-20090045/URN_NBN_fi_joy-20090045.pdf
Namibia	Bethanie	2002	https://epublications.uef.fi/pub/URN_NBN_fi_joy-20090045/URN_NBN_fi_joy-20090045.pdf
Namibia	Karasburg	2002	https://epublications.uef.fi/pub/URN_NBN_fi_joy-20090045/URN_NBN_fi_joy-20090045.pdf
Namibia	Keetmanshoop	1999	https://epublications.uef.fi/pub/URN_NBN_fi_joy-20090045/URN_NBN_fi_joy-20090045.pdf
Namibia	Lüderitz	2002	https://epublications.uef.fi/pub/URN_NBN_fi_joy-20090045/URN_NBN_fi_joy-20090045.pdf
Namibia	Oranjemund	1999	https://www.oodaloop.com/documents/Legacy/CIA/factbook/geos/wa.html
Namibia	Rundu	2002	https://www.namibweb.com/namtel.htm
Namibia	Windhoek	1999	https://www.namibweb.com/namtel.htm
Namibia	Opuwo	2002	http://home.intekom.com/intekom/clients/t/telecom_namibia/technology.stm
Namibia	Oshikango	2002	http://home.intekom.com/intekom/clients/t/telecom_namibia/technology.stm
Namibia	Gobabis	2002	https://epublications.uef.fi/pub/URN_NBN_fi_joy-20090045/URN_NBN_fi_joy-20090045.pdf
Namibia	Grootfontein	2002	https://www.namibweb.com/namtel.htm
Namibia	Otjiwarongo	2002	https://epublications.uef.fi/pub/URN_NBN_fi_joy-20090045/URN_NBN_fi_joy-20090045.pdf
Namibia	Katima Mulilo	2002	https://www.namibweb.com/namtel.htm
Niger	Dosso	2007	http://www.infodev.org/infodev-files/resource/InfodevDocuments_421.pdf
Niger	Gaya	2007	http://www.infodev.org/infodev-files/resource/InfodevDocuments_421.pdf
Niger	Niamey	2006	https://www.commsupdate.com/articles/2006/11/23/sonitel-fibre-optic-network-inaugurated/
Nigeria	Aba	2003	https://at.linkedin.com/in/josefweingand
Nigeria	Umuahia	2003	https://at.linkedin.com/in/josefweingand
Nigeria	Mubi	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Numan	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Yola	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Uyo	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Awka	2003	https://at.linkedin.com/in/josefweingand
Nigeria	Onitsha	2003	https://at.linkedin.com/in/josefweingand

Table continues on the next page.

Country	city/town	connection	URL source
Nigeria	Azare	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Bauchi	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Makurdi	2008	https://www.commsupdate.com/articles/2008/07/16/globacom-in-ongoing-rollout/
Nigeria	Oturkpo	2008	https://www.commsupdate.com/articles/2008/07/16/globacom-in-ongoing-rollout/
Nigeria	Bama	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Maiduguri	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Calabar	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Sapele	2008	https://www.commsupdate.com/articles/2008/07/16/globacom-in-ongoing-rollout/
Nigeria	Warri	2008	https://www.commsupdate.com/articles/2008/07/16/globacom-in-ongoing-rollout/
Nigeria	Benin City	2003	https://at.linkedin.com/in/josefweingand
Nigeria	Ado Ekiti	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Enugu	2003	https://at.linkedin.com/in/josefweingand
Nigeria	Abuja	2003	https://at.linkedin.com/in/josefweingand
Nigeria	Gombe	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Owerri	2008	https://www.commsupdate.com/articles/2008/07/16/globacom-in-ongoing-rollout/
Nigeria	Dutse	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Kaduna	2007	https://www.commsupdate.com/articles/2007/11/23/globacom-commissions-nationwide-fibre-optic-programme/
Nigeria	Zaria	2007	https://www.commsupdate.com/articles/2007/11/23/globacom-commissions-nationwide-fibre-optic-programme/
Nigeria	Kano	2007	https://www.commsupdate.com/articles/2007/11/23/globacom-commissions-nationwide-fibre-optic-programme/
Nigeria	Funtua	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Katsina	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Birnin Kebbi	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Lokoja	2003	https://at.linkedin.com/in/josefweingand
Nigeria	Ilorin	2008	https://www.commsupdate.com/articles/2008/07/16/globacom-in-ongoing-rollout/
Nigeria	Lagos	2001	https://www.submarinenetworks.com/en/systems/euro-africa/sat-3
Nigeria	Keffi	2008	https://www.commsupdate.com/articles/2008/07/16/globacom-in-ongoing-rollout/
Nigeria	Lafia	2008	https://www.commsupdate.com/articles/2008/07/16/globacom-in-ongoing-rollout/
Nigeria	Bida	2008	https://www.commsupdate.com/articles/2008/07/16/globacom-in-ongoing-rollout/
Nigeria	Minna	2008	https://www.commsupdate.com/articles/2008/07/16/globacom-in-ongoing-rollout/
Nigeria	Kontagora	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Abeokuta	2007	https://www.commsupdate.com/articles/2007/11/23/globacom-commissions-nationwide-fibre-optic-programme/
Nigeria	Ijebu Ode	2003	https://at.linkedin.com/in/josefweingand
Nigeria	Akure	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Ondo	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Owo	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Ife	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Oshogbo	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Ibadan	2003	https://at.linkedin.com/in/josefweingand
Nigeria	Ogbomosho	2008	https://www.commsupdate.com/articles/2008/07/16/globacom-in-ongoing-rollout/
Nigeria	Oyo	2008	https://www.commsupdate.com/articles/2008/07/16/globacom-in-ongoing-rollout/
Nigeria	Jos	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Port Harcourt	2003	https://at.linkedin.com/in/josefweingand
Nigeria	Sokoto	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Damaturu	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Potiskum	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Nigeria	Gusau	2009	http://documents.worldbank.org/curated/en/684121468010226781/pdf/536430PUB0Broa101Official0Use0Only1.pdf
Rwanda	Kibungo	2009	https://www.commsupdate.com/articles/2008/07/22/nationwide-backbone-to-be-completed-by-november-2009/
Rwanda	Kigali	2009	https://www.commsupdate.com/articles/2008/07/22/nationwide-backbone-to-be-completed-by-november-2009/
Rwanda	Byumba	2009	https://www.commsupdate.com/articles/2008/07/22/nationwide-backbone-to-be-completed-by-november-2009/
Rwanda	Butare	2009	https://www.commsupdate.com/articles/2008/07/22/nationwide-backbone-to-be-completed-by-november-2009/
Rwanda	Gitarama	2009	https://www.commsupdate.com/articles/2008/07/22/nationwide-backbone-to-be-completed-by-november-2009/
Rwanda	Nyanza	2009	https://www.commsupdate.com/articles/2008/07/22/nationwide-backbone-to-be-completed-by-november-2009/
Senegal	Dakar	2000	https://web.archive.org/web/20110927174252/http://www.convergedigest.com/Daily/v7/v7n092.htm
Senegal	Diourbel	2000	https://www.itu.int/osg/spu/wtpf/wtpf98/cases/Senegal/senegf1.pdf
Senegal	Fatick	2001	http://www.polis.sciencespobordeaux.fr/resultats/documents/externes/Guignard_DEA.pdf
Senegal	Kaolack	2001	http://www.polis.sciencespobordeaux.fr/resultats/documents/externes/Guignard_DEA.pdf
Senegal	Kolda	2001	http://www.polis.sciencespobordeaux.fr/resultats/documents/externes/Guignard_DEA.pdf
Senegal	Louga	2000	https://www.itu.int/osg/spu/wtpf/wtpf98/cases/Senegal/senegf1.pdf
Senegal	Dial	2000	https://www.itu.int/osg/spu/wtpf/wtpf98/cases/Senegal/senegf1.pdf

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Country	city/town	connection	URL source
Senegal	Matam	2000	https://www.itu.int/osg/spu/wtpf/wtpf98/cases/Senegal/senegf1.pdf
Senegal	Saint-Louis	2000	https://www.itu.int/osg/spu/wtpf/wtpf98/cases/Senegal/senegf1.pdf
Senegal	Kidira	2000	https://www.itu.int/osg/spu/wtpf/wtpf98/cases/Senegal/senegf1.pdf
Senegal	Tambacounda	2001	http://www.polis.sciencespobordeaux.fr/resultats/documents/externes/Guignard_DEA.pdf
Senegal	Thiès	2000	https://www.itu.int/osg/spu/wtpf/wtpf98/cases/Senegal/senegf1.pdf
Senegal	Ziguinchor	2001	http://www.polis.sciencespobordeaux.fr/resultats/documents/externes/Guignard_DEA.pdf
South Africa	Bhisho	1999	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	East London	1999	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Graaff Reinet	2009	No sufficient sources
South Africa	Grahamstown	1999	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Port Alfred	2009	No sufficient sources
South Africa	Cradock	2009	No sufficient sources
South Africa	Middelburg	2009	No sufficient sources
South Africa	Queenstown	2009	No sufficient sources
South Africa	Aliwal North	2009	No sufficient sources
South Africa	Port Elizabeth	1999	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Uitenhage	1999	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Umtata	1999	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Port St. Johns	2009	No sufficient sources
South Africa	Johannesburg	1995	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Pretoria	1999	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Springs	2009	No sufficient sources
South Africa	Vereeniging	2009	No sufficient sources
South Africa	Durban	1999	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Port Shepstone	1999	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Pietermaritzburg	1999	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Ubomba	2009	No sufficient sources
South Africa	Ladysmith	1999	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Mtuzini	2002	https://www.submarinenetworks.com/en/systems/euro-africa/sat-3
South Africa	Ulundi	2009	No sufficient sources
South Africa	Vryheid	2009	No sufficient sources
South Africa	Lebowakgomo	2009	No sufficient sources
South Africa	Polokwane	2004	https://www.commsupdate.com/articles/2004/08/25/tel-one-rolls-out-radio-link-to-south-africa/
South Africa	Tzaneen	2009	No sufficient sources
South Africa	Musina	2004	https://www.commsupdate.com/articles/2004/08/25/tel-one-rolls-out-radio-link-to-south-africa/
South Africa	Thohoyandou	2009	No sufficient sources
South Africa	Komatipoort	2006	https://www.fomsn.com/networks/fiber/fiber-optic-network-links-mozambique-and-south-africa/
South Africa	Mbombela	2006	https://www.fomsn.com/networks/fiber/fiber-optic-network-links-mozambique-and-south-africa/
South Africa	Bethal	2009	No sufficient sources
South Africa	Standerton	2009	No sufficient sources
South Africa	Volksrust	2009	No sufficient sources
South Africa	Middelburg	2006	https://www.fomsn.com/networks/fiber/fiber-optic-network-links-mozambique-and-south-africa/
South Africa	Brits	2004	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
South Africa	Rustenburg	2004	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
South Africa	Klerksdorp	2009	No sufficient sources
South Africa	Potchefstroom	2009	No sufficient sources
South Africa	Bloemhof	2009	No sufficient sources
South Africa	Vryburg	2009	No sufficient sources
South Africa	Mmabatho	2004	https://researchictafrica.net/publications/Evidence_for_ICT_Policy_Action/Policy_Paper_1_-_Understanding_what_is_happening_in_ICT_in_Botswana.pdf
South Africa	Kimberley	2009	No sufficient sources
South Africa	Poffader	2009	No sufficient sources
South Africa	Springbok	1999	.https://www.oodaloop.com/documents/Legacy/CIA/factbook/geos/wa.html
South Africa	Alexander Bay	1999	.https://www.oodaloop.com/documents/Legacy/CIA/factbook/geos/wa.html
South Africa	Carnarvon	2009	No sufficient sources
South Africa	Colesberg	2009	No sufficient sources
South Africa	De Aar	2009	No sufficient sources
South Africa	Prieska	2009	No sufficient sources
South Africa	Kroonstad	2009	No sufficient sources
South Africa	Welkom	2009	No sufficient sources
South Africa	Bloemfontein	1999	https://www.telkom.co.za/history/TelkomHistory/index.html

Table continues on the next page.

Country	city/town	connection	URL source
South Africa	Bethlehem	2009	No sufficient sources
South Africa	Paarl	1995	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Worcester	1995	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Beaufort West	1995	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Melkbosstrand	1993	https://www.submarinenetworks.com/en/stations/africa/south-africa/melkbosstrand-cls
South Africa	Cape Town	1993	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	George	1999	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Mossel Bay	1999	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Oudtshoorn	2009	No sufficient sources
South Africa	Bredasdorp	2009	No sufficient sources
South Africa	Hermanus	2009	No sufficient sources
South Africa	Swellendam	1999	https://www.telkom.co.za/history/TelkomHistory/index.html
South Africa	Saldanha	1999	.https://www.oodaloop.com/documents/Legacy/CIA/factbook/geos/wa.html
South Africa	Vanhynsdorp	1999	.https://www.oodaloop.com/documents/Legacy/CIA/factbook/geos/wa.html
Sudan	El Manaqil	2005	https://acir.yale.edu/sites/default/files/files/YaleLowensteinSudanReport.pdf
Sudan	Wad Madani	2004	https://books.google.de/books?id=WAs7lGNkVBkC&pg=PA217&lpg=PA217&dq=fiber+optic+cable+sudan+2004&source=bl&ots=cK8Dtz-0UR&sig=ACfU3U0ifVfHqC23ZJDM79R00SUWuBx3cQ&hl=de&sa=X&ved=2ahUKEwjzsYbnlJjqAhUHGuwKHbS1B2gQ6AEw-AHoECAkQAQ#v=onepage&q=fiber%20optic%20cable%20sudan%202004&f=false
Sudan	Ad Damazin	2005	https://acir.yale.edu/sites/default/files/files/YaleLowensteinSudanReport.pdf
Sudan	Gedaref	2004	https://books.google.de/books?id=WAs7lGNkVBkC&pg=PA217&lpg=PA217&dq=fiber+optic+cable+sudan+2004&source=bl&ots=cK8Dtz-0UR&sig=ACfU3U0ifVfHqC23ZJDM79R00SUWuBx3cQ&hl=de&sa=X&ved=2ahUKEwjzsYbnlJjqAhUHGuwKHbS1B2gQ6AEw-AHoECAkQAQ#v=onepage&q=fiber%20optic%20cable%20sudan%202004&f=false
Sudan	Kassala	2004	https://books.google.de/books?id=WAs7lGNkVBkC&pg=PA217&lpg=PA217&dq=fiber+optic+cable+sudan+2004&source=bl&ots=cK8Dtz-0UR&sig=ACfU3U0ifVfHqC23ZJDM79R00SUWuBx3cQ&hl=de&sa=X&ved=2ahUKEwjzsYbnlJjqAhUHGuwKHbS1B2gQ6AEw-AHoECAkQAQ#v=onepage&q=fiber%20optic%20cable%20sudan%202004&f=false
Sudan	Khartoum	2004	https://books.google.de/books?id=WAs7lGNkVBkC&pg=PA217&lpg=PA217&dq=fiber+optic+cable+sudan+2004&source=bl&ots=cK8Dtz-0UR&sig=ACfU3U0ifVfHqC23ZJDM79R00SUWuBx3cQ&hl=de&sa=X&ved=2ahUKEwjzsYbnlJjqAhUHGuwKHbS1B2gQ6AEw-AHoECAkQAQ#v=onepage&q=fiber%20optic%20cable%20sudan%202004&f=false
Sudan	Omdurman	2004	https://books.google.de/books?id=WAs7lGNkVBkC&pg=PA217&lpg=PA217&dq=fiber+optic+cable+sudan+2004&source=bl&ots=cK8Dtz-0UR&sig=ACfU3U0ifVfHqC23ZJDM79R00SUWuBx3cQ&hl=de&sa=X&ved=2ahUKEwjzsYbnlJjqAhUHGuwKHbS1B2gQ6AEw-AHoECAkQAQ#v=onepage&q=fiber%20optic%20cable%20sudan%202004&f=false
Sudan	El Fasher	2005	https://acir.yale.edu/sites/default/files/files/YaleLowensteinSudanReport.pdf
Sudan	El Obeid	2004	https://books.google.de/books?id=WAs7lGNkVBkC&pg=PA217&lpg=PA217&dq=fiber+optic+cable+sudan+2004&source=bl&ots=cK8Dtz-0UR&sig=ACfU3U0ifVfHqC23ZJDM79R00SUWuBx3cQ&hl=de&sa=X&ved=2ahUKEwjzsYbnlJjqAhUHGuwKHbS1B2gQ6AEw-AHoECAkQAQ#v=onepage&q=fiber%20optic%20cable%20sudan%202004&f=false
Sudan	Dongola	2004	https://www.sudantribune.com/spip.php?article6196
Sudan	Merowe	2004	https://www.sudantribune.com/spip.php?article6196
Sudan	Wadi Halfa	2004	https://www.sudantribune.com/spip.php?article6196
Sudan	Haiya	2004	https://books.google.de/books?id=WAs7lGNkVBkC&pg=PA217&lpg=PA217&dq=fiber+optic+cable+sudan+2004&source=bl&ots=cK8Dtz-0UR&sig=ACfU3U0ifVfHqC23ZJDM79R00SUWuBx3cQ&hl=de&sa=X&ved=2ahUKEwjzsYbnlJjqAhUHGuwKHbS1B2gQ6AEw-AHoECAkQAQ#v=onepage&q=fiber%20optic%20cable%20sudan%202004&f=false
Sudan	Port Sudan	2003	http://www.fiberatlantic.com/system/YE5Ln
Sudan	Atbara	2004	https://books.google.de/books?id=WAs7lGNkVBkC&pg=PA217&lpg=PA217&dq=fiber+optic+cable+sudan+2004&source=bl&ots=cK8Dtz-0UR&sig=ACfU3U0ifVfHqC23ZJDM79R00SUWuBx3cQ&hl=de&sa=X&ved=2ahUKEwjzsYbnlJjqAhUHGuwKHbS1B2gQ6AEw-AHoECAkQAQ#v=onepage&q=fiber%20optic%20cable%20sudan%202004&f=false
Sudan	Berber	2005	https://acir.yale.edu/sites/default/files/files/YaleLowensteinSudanReport.pdf
Sudan	Sennar	2004	https://books.google.de/books?id=WAs7lGNkVBkC&pg=PA217&lpg=PA217&dq=fiber+optic+cable+sudan+2004&source=bl&ots=cK8Dtz-0UR&sig=ACfU3U0ifVfHqC23ZJDM79R00SUWuBx3cQ&hl=de&sa=X&ved=2ahUKEwjzsYbnlJjqAhUHGuwKHbS1B2gQ6AEw-AHoECAkQAQ#v=onepage&q=fiber%20optic%20cable%20sudan%202004&f=false
Sudan	Nyala	2004	https://books.google.de/books?id=WAs7lGNkVBkC&pg=PA217&lpg=PA217&dq=fiber+optic+cable+sudan+2004&source=bl&ots=cK8Dtz-0UR&sig=ACfU3U0ifVfHqC23ZJDM79R00SUWuBx3cQ&hl=de&sa=X&ved=2ahUKEwjzsYbnlJjqAhUHGuwKHbS1B2gQ6AEw-AHoECAkQAQ#v=onepage&q=fiber%20optic%20cable%20sudan%202004&f=false
Sudan	Babanusa	2004	https://books.google.de/books?id=WAs7lGNkVBkC&pg=PA217&lpg=PA217&dq=fiber+optic+cable+sudan+2004&source=bl&ots=cK8Dtz-0UR&sig=ACfU3U0ifVfHqC23ZJDM79R00SUWuBx3cQ&hl=de&sa=X&ved=2ahUKEwjzsYbnlJjqAhUHGuwKHbS1B2gQ6AEw-AHoECAkQAQ#v=onepage&q=fiber%20optic%20cable%20sudan%202004&f=false
Sudan	Geneina	2005	https://acir.yale.edu/sites/default/files/files/YaleLowensteinSudanReport.pdf

Table continues on the next page.

Country	city/town	connection	URL source
Sudan	Muglad	2005	https://acir.yale.edu/sites/default/files/files/YaleLowensteinSudanReport.pdf
Sudan	Ed Dueim	2005	https://acir.yale.edu/sites/default/files/files/YaleLowensteinSudanReport.pdf
Sudan	Kosti	2004	https://books.google.de/books?id=WAs7lGNkVBkC&pg=PA217&lpg=PA217&dq=fiber+optic+cable+sudan+2004&source=bl&ots=cK8Dtz-0UR&sig=ACfU3U0ifVfHqC23ZJDM79R00SUWuBx3cQ&hl=de&sa=X&ved=2ahUKEwjzsYbnlJjqAhUHGuwKHbS1B2gQ6AEw-AHoECAkQAQ#v=onepage&q=fiber%20optic%20cable%20sudan%202004&f=false
Swaziland	Mbabane	2008	https://www.budde.com.au/Research/Eswatini-Swaziland-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses
Swaziland	Piggs Peak	2009	https://books.google.de/books?id=oJutDwAAQBAJ&pg=PA196&lpg=PA196&dq=fiber+optic+network+swaziland+2008&source=bl&ots=F9C9z-OGFaG&sig=ACfU3U2RGIsygPIUq0exvMLmsMn2uq3pmg&hl=de&sa=X&ved=2ahUKEwiPj-TSnanqAhVF3KQKHf2jCDQQ6AEw-AHoECAcQAQ#v=onepage&q=fiber%20optic%20network%20swaziland%202008&f=false
Swaziland	Siteki	2009	https://books.google.de/books?id=oJutDwAAQBAJ&pg=PA196&lpg=PA196&dq=fiber+optic+network+swaziland+2008&source=bl&ots=F9C9z-OGFaG&sig=ACfU3U2RGIsygPIUq0exvMLmsMn2uq3pmg&hl=de&sa=X&ved=2ahUKEwiPj-TSnanqAhVF3KQKHf2jCDQQ6AEw-AHoECAcQAQ#v=onepage&q=fiber%20optic%20network%20swaziland%202008&f=false
Swaziland	Manzini	2009	https://books.google.de/books?id=oJutDwAAQBAJ&pg=PA196&lpg=PA196&dq=fiber+optic+network+swaziland+2008&source=bl&ots=F9C9z-OGFaG&sig=ACfU3U2RGIsygPIUq0exvMLmsMn2uq3pmg&hl=de&sa=X&ved=2ahUKEwiPj-TSnanqAhVF3KQKHf2jCDQQ6AEw-AHoECAcQAQ#v=onepage&q=fiber%20optic%20network%20swaziland%202008&f=false
Swaziland	Lavumisa	2009	https://books.google.de/books?id=oJutDwAAQBAJ&pg=PA196&lpg=PA196&dq=fiber+optic+network+swaziland+2008&source=bl&ots=F9C9z-OGFaG&sig=ACfU3U2RGIsygPIUq0exvMLmsMn2uq3pmg&hl=de&sa=X&ved=2ahUKEwiPj-TSnanqAhVF3KQKHf2jCDQQ6AEw-AHoECAcQAQ#v=onepage&q=fiber%20optic%20network%20swaziland%202008&f=false
Tanzania	Arusha	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Dar es Salaam	2009	https://www.zuj.edu.jo/conferences/ICIT11/PaperList/Papers/Computer%20Networks%20&%20Communications/627_Koloseni.pdf
Tanzania	Dodoma	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Moshi	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Same	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Lindi	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Babati	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Kilosa	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Morogoro	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Kibiti	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Manyoni	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Singida	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Tabora	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Tanga	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Togo	Sokodé	2005	https://books.google.de/books?id=Hqt8eQNuRaoC&pg=PA41&lpg=PA41&dq=fiber+optic+cable+togo+burkina+faso+2006&source=bl&ots=A-zya4sPwq&sig=ACfU3U0Lv-bGFR3LrEJmvI7ir-7JI1NS3A&hl=de&sa=X&ved=2ahUKEwi6-4WpxIbqAhXKjqQKHcR0CbAQ6AEw-AHoECAcQAQ#v=onepage&q=fiber%20optic%20cable%20togo%20burkina%20faso%202006&f=false
Togo	Sotouboua	2005	https://books.google.de/books?id=Hqt8eQNuRaoC&pg=PA41&lpg=PA41&dq=fiber+optic+cable+togo+burkina+faso+2006&source=bl&ots=A-zya4sPwq&sig=ACfU3U0Lv-bGFR3LrEJmvI7ir-7JI1NS3A&hl=de&sa=X&ved=2ahUKEwi6-4WpxIbqAhXKjqQKHcR0CbAQ6AEw-AHoECAcQAQ#v=onepage&q=fiber%20optic%20cable%20togo%20burkina%20faso%202006&f=false
Togo	Lomé	2005	https://books.google.de/books?id=Hqt8eQNuRaoC&pg=PA41&lpg=PA41&dq=fiber+optic+cable+togo+burkina+faso+2006&source=bl&ots=A-zya4sPwq&sig=ACfU3U0Lv-bGFR3LrEJmvI7ir-7JI1NS3A&hl=de&sa=X&ved=2ahUKEwi6-4WpxIbqAhXKjqQKHcR0CbAQ6AEw-AHoECAcQAQ#v=onepage&q=fiber%20optic%20cable%20togo%20burkina%20faso%202006&f=false
Togo	Atakpamé	2005	https://books.google.de/books?id=Hqt8eQNuRaoC&pg=PA41&lpg=PA41&dq=fiber+optic+cable+togo+burkina+faso+2006&source=bl&ots=A-zya4sPwq&sig=ACfU3U0Lv-bGFR3LrEJmvI7ir-7JI1NS3A&hl=de&sa=X&ved=2ahUKEwi6-4WpxIbqAhXKjqQKHcR0CbAQ6AEw-AHoECAcQAQ#v=onepage&q=fiber%20optic%20cable%20togo%20burkina%20faso%202006&f=false
Togo	Mango	2005	https://books.google.de/books?id=Hqt8eQNuRaoC&pg=PA41&lpg=PA41&dq=fiber+optic+cable+togo+burkina+faso+2006&source=bl&ots=A-zya4sPwq&sig=ACfU3U0Lv-bGFR3LrEJmvI7ir-7JI1NS3A&hl=de&sa=X&ved=2ahUKEwi6-4WpxIbqAhXKjqQKHcR0CbAQ6AEw-AHoECAcQAQ#v=onepage&q=fiber%20optic%20cable%20togo%20burkina%20faso%202006&f=false
Uganda	Kampala	2009	https://www.commsupdate.com/articles/2006/06/13/mtn-uganda-extends-fibre-optic-network/
Uganda	Masaka	2009	https://www.commsupdate.com/articles/2006/06/13/mtn-uganda-extends-fibre-optic-network/
Uganda	Entebbe	2009	https://www.commsupdate.com/articles/2006/06/13/mtn-uganda-extends-fibre-optic-network/
Uganda	Busia	2009	https://www.commsupdate.com/articles/2009/07/07/kdn-builds-out-seacom-link/
Uganda	Jinja	2009	https://www.commsupdate.com/articles/2006/06/13/mtn-uganda-extends-fibre-optic-network/
Uganda	Tororo	2009	https://www.commsupdate.com/articles/2009/07/07/kdn-builds-out-seacom-link/
Uganda	Mbarara	2009	https://www.commsupdate.com/articles/2006/06/13/mtn-uganda-extends-fibre-optic-network/

Table continues on the next page.

Country	city/town	connection	URL source
Zambia	Kabwe	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Kapiri Mposhi	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Chililabombwe	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Chingola	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Kitwe	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Luanshya	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Mufulira	2009	https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.scribd.com%2Fdocument%2F274569230%2FZe-Scoop-Tic-Phase-i-i-20062012&psig=AOvVaw3VnkgSbaRyyBKkKOcAVBcN&ust=1593259795755000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCNCu1MC5n-oCFQAAAAAdAAAAABAY
Zambia	Ndola	2009	https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.scribd.com%2Fdocument%2F274569230%2FZe-Scoop-Tic-Phase-i-i-20062012&psig=AOvVaw3VnkgSbaRyyBKkKOcAVBcN&ust=1593259795755000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCNCu1MC5n-oCFQAAAAAdAAAAABAY
Zambia	Lusaka	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Solwezi	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Choma	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Kafue	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Livingstone	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Mazabuka	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Sesheke	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zimbabwe	Bulawayo	2004	https://www.commsupdate.com/articles/2004/08/25/tel-one-rolls-out-radio-link-to-south-africa/
Zimbabwe	Harare	2004	https://www.commsupdate.com/articles/2004/08/25/tel-one-rolls-out-radio-link-to-south-africa/
Zimbabwe	Mutare	2009	https://ppiaf.org/documents/3160/download
Zimbabwe	Chinhoyi	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zimbabwe	Kadoma	2004	https://www.commsupdate.com/articles/2004/08/25/tel-one-rolls-out-radio-link-to-south-africa/
Zimbabwe	Kariba	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zimbabwe	Karoi	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zimbabwe	Victoria Falls	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zimbabwe	Beitbridge	2004	https://www.commsupdate.com/articles/2004/08/25/tel-one-rolls-out-radio-link-to-south-africa/
Zimbabwe	Gweru	2004	https://www.commsupdate.com/articles/2004/08/25/tel-one-rolls-out-radio-link-to-south-africa/
Zimbabwe	Kwekwe	2004	https://www.commsupdate.com/articles/2004/08/25/tel-one-rolls-out-radio-link-to-south-africa/

Note: Source URLs last accessed in June and July, 2020. Extensive documentation and copies of primary sources available upon request. *Source:* Own research.