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

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Abstract

We investigate the impact of early internet availability at basic speeds on local economic development in remote areas of developing countries by analyzing nighttime light emissions across towns in SubSaharan Africa. Using a difference-in-differences approach, we exploit submarine cable arrivals, which established countrywide internet connections, and the rollout of the national backbones, which defines internet access within countries. Estimating on incidentally connected mid-sized towns, we find that early internet availability increases nighttime light intensity by 10 percent. We consider increased employment as the main explanation. Our findings highlight the importance of closing the digital divide for regional development.

Keywords: ICT, Economic Development, Nighttime Lights, Sub-Saharan Africa, Cybercafé, Internet Access, Employment, Submarine Cables

JEL Codes: O18, R11, L96

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1. Introduction

In Sub-Saharan Africa (SSA), where impulses for economic development are urgently needed to combat poverty, substantial investments are being made in internet infrastructure by governments, public-private partnerships, and private consortia.[4] However, the provision of internet access is complex and costly due to the lack of legacy infrastructure, such as fixed-line telephony networks, and low population density outside major cities (Williams, 2010).[5] The unique challenges of missing hardware, financial constraints, and a low willingness to pay lead to low adoption rates in SSA (World Bank, 2016), raising questions about the economic impact of such investments. Still, the potential benefits of internet access in SSA are particularly high given the absence of alternative ICT infrastructure (ITU, 2019). Given the large investments and unclear economic benefits, it is crucial to understand how internet availability affects local economic development in SSA, especially in remote areas where provision is particularly costly.

In this paper, we examine how the introduction of early internet availability at basic speeds affects local economic development in remote towns in SSA. In contrast to the existing literature that investigates the effects of higher speeds (e.g., Hjort and Poulsen, 2019; D'Andrea and Limodio, 2024) or mobile internet (e.g., Bahia et al., 2024; Chiplunkar and Goldberg, 2022), we focus on the extensive margin of internet provision in a developing country setting by studying the first towns that gain internet access.[6] We track economic activity at the town level in response to plausibly exogenous shocks in local internet availability by applying an inconsequential treatment approach (Redding and Turner, 2015). We find that towns with early internet access experience a 10 percent increase in nighttime light (NTL) intensity in the five years after countrywide internet connection in comparison to towns gaining internet access later. Our findings suggest productivity gains and, using georeferenced Demographic and Health Surveys (DHS), an employment increase of 9.3 percentage points, particularly in low-skilled jobs and for women.

Our baseline sample captures the evolution of 184 towns in ten SSA countries provided with the first countrywide internet connection between 2000 and 2007 and a national backbone established prior to this outside larger cities. We tap two main data sources. First, we measure

[4] Investments into SSA's terrestrial internet national backbone exceeded 28 billion USD by 2020 (Hamilton Research, 2020). Moreover, China alone plans to invest more than 60 billion USD in Africa's digital infrastructure as part of its 'Belt and Road' initiative (Invesco, 2019).

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

[6] Guriev et al. (2020) and Adema et al. (2022) investigate mobile internet as well and have a more global than developing country focus.

local economic development using NTL satellite data and assign NTL intensity to towns (e.g., Henderson et al., 2018; Campante and Yanagizawa-Drott, 2018; Storeygard, 2016). Second, we use data on the rollout of the national backbone from Hamilton Research (2020) to measure internet access at the town level. To extend the data backward to the late 1990s, we conduct an extensive review of national backbone deployment projects to assign the actual construction years to access points. This enables us to study the early and mid-2000s when the first wave of submarine cable (SMC) arrivals brought internet availability to SSA for the first time at a noticeable scale.[7]

To identify the effect of early internet availability on local economic development, we exploit quasi-random variation in the timing of countrywide internet connection induced by the arrival of the first wave of SMCs in SSA.[8] In a difference-in-differences framework, we define treatment and control group towns exploiting the rollout of the national backbone. The rollout of the national backbone aims to connect political and economic centers (Williams, 2010). Importantly, towns located on-route between such 'nodal cities' typically receive access points as well. To avoid a selection bias from economically and politically significant 'nodal cities', we focus on smaller – incidentally connected – remote towns (Redding and Turner, 2015). Only if the country is connected via an SMC and the town has access to the national backbone via a nearby access point, internet is available in the town. We, thus, assign the treatment status to towns that had access to the national backbone when the internet became available countrywide, while the control group consists of (similarly-sized) towns receiving their access point only later. At the time, people access the internet predominantly in cybercafés (Southwood, 2022). However, we do not observe internet usage and, thus, estimate reduced form effects.

To ensure that our results are indeed driven by internet availability, we control for a rich set of potential confounding factors. First, in addition to town fixed effects, we use country-year fixed effects to control for country-specific growth paths. Next, we control for the rollout of mobile coverage as a second digital infrastructure.[9] Our empirical model further takes into account potential changes in the importance of geographic fundamentals over time.

[7] Internet connections were already possible before. However, they had a very limited user base, as they were either satellite-based (e.g. VSAT) or telephony-based (Williams, 2010; Nyezi, 2012), both of which are very expensive and only allow narrow bandwidths. First-wave SMCs allowed for speeds between 0.5 and 2Mbps, enabling basic functionality like e-mail and web browsing.

[8] 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.

[9] During our observation period, mobile internet was unavailable. All countries only had basic mobile coverage, which enables calls and SMS messaging, but not surfing the web.

Importantly, we control for the distance to the capital city, interacted with the connection indicator, to account for potential spillover effects of metropolitan areas. NTL emissions are associated with electricity consumption. Therefore, we restrict the sample to towns with NTL emissions in each year from 1995 onward to preclude the increase in NTL emissions originating from the rollout of the electricity grid. 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, but event study specifications show that there are no differences in pretreatment trends. This holds independent of the inclusion of the controls and is reassuring of our assumption.

We show three sets of results. First, we find that early internet availability leads, on average, to a 10 percent increase over a period of six years in NTL intensity of towns in the years after countrywide internet connection compared to a control group of towns not connected through an access point at that time. Applying the established NTL-to-GDP elasticity from Henderson et al. (2012), this translates to about 3.0 percentage points higher economic growth. We then decompose this overall effect into measures for intensive- and extensive-margin growth and investigate changes in population density using high-resolution grids from *Gridded Population of the World*. The results point toward an increase in per-capita productivity rather than a spatial redistribution of economic activity. These findings add two important contributions to Hjort and Poulsen (2019). It is likely that the introduction of internet availability at basic speeds has economic effects different from those of an internet speed upgrade. Moreover, individual-level employment increases do not necessarily lead to measurable aggregate effects at the town level. While Hjort and Poulsen (2019) focuses on skill-biased technical change and labor market effects, our study highlights the aggregate effects and shows that towns being connected earlier develop faster in comparison to later connected towns.

Second, we provide accompanying individual-level estimations on employment effects using georeferenced DHS. We find an employment increase of 9.3 percentage points, with slightly higher estimates for women. This increase mainly originates from low-skilled employment. For a later time period, Hjort and Poulsen (2019) report similar findings for overall employment, whereas Bahia et al. (2024) observe smaller increases in overall employment. Both studies, however, note stronger effects on high-skilled employment.

Finally, we present migration effects. We show that the likelihood of non-movers decreases in treated towns, with slightly higher estimates for better-educated individuals. This implies that towns with internet access become more attractive, particularly for this group. For the likelihood of having moved recently, we find stronger effects for males and, again, for bettereducated individuals. Unfortunately, we cannot investigate emigrants. However, by analyzing the towns' composition and thereby investigating migration indirectly, we find a decline in better-educated individuals. This indicates that high-skilled workers emigrate to larger cities and is in line with Adema et al. (2022) who find that mobile internet leads to a higher desire to migrate. Moreover, it can explain better our employment results.

Apart from absent pre-trends, placebo tests corroborate that the effect on local economic development is tied to the unique structure of the exogenous variation we exploit. It is, therefore, unlikely that the treatment is confounded by parallel infrastructure rollouts. Nevertheless, we assess this possibility more directly using DHS household responses on electricity availability and find no evidence in support of a parallel rollout of electricity grids. We assess further robustness of our results to alternative model specifications, in particular with respect to the composition of the control group and measurement approaches.

There is a large literature finding positive economic effects of fixed-line internet in developed countries (e.g., Akerman et al., 2015; Kolko, 2012; Czernich et al., 2011). For developing countries, Hjort and Tian (2025) survey the evolving literature on the economic impact of internet connectivity.[10] Much of this literature is focused on mobile internet since around 2010, as mobile phones are the main technology through which individuals access the internet in developing countries since then (e.g., Chiplunkar and Goldberg, 2022; Williams et al., 2011; Aker and Mbiti, 2010). Several recent studies examine the effect of mobile internet availability in developing countries in the 2010s and consistently find an increase in consumption and a reduction in poverty, e.g., in Nigeria (Bahia et al., 2024), Senegal (Masaki et al., 2020), and Tanzania (Bahia et al., 2021).[11] Closely related to our study are Hjort and Poulsen (2019) and Mensah (2021). Mensah estimates increases in NTL intensity induced by 2G and 3G mobile coverage globally. Hjort and Poulsen 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 investigate development, employment, and migration effects of early internet availability at basic speeds

[10] For developing countries, there is an established literature for non-digital infrastructure, most importantly transportation (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 (e.g., Moneke, 2020; Mensah, 2024; Lee et al., 2020; Lipscomb et al., 2013; Rud, 2012; Dinkelman, 2011). Although not in all settings, this literature largely finds infrastructure beneficial for regional development.

[11] 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 an RCT distributing free phone data in Kenya. Rotondi et al. (2020) find an effect of mobile phone coverage and ownership on rural development in developing countries.

when the internet became available in 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. With the notable exceptions of Jensen (2007) and Manacorda and Tesei (2020), the literature neglects the important era when ICT became first available in the developing world.

Although the regional digital divide is widely discussed (e.g., Rotondi et al., 2020; Lagakos, 2020; Fukui et al., 2019; Buys et al., 2009), only a few studies investigate the impacts of digital infrastructure on remote areas outside of large cities (e.g., Hjort and Poulsen, 2019). Apart from the regional digital divide, most studies compare economic progress between primates and secondary cities, often with inconclusive findings regarding inequality trends (e.g., Bluhm and Krause, 2022; Christiaensen and Kanbur, 2017). There is a notable gap in the literature concerning smaller, more remote agglomerations. Our work addresses this gap by demonstrating that connectivity effectively contributes to narrowing the digital divide in smaller, remote towns in developing countries. Although we cannot compare relative development between these towns and larger agglomerations, our findings show that unconnected towns fall further behind compared to their incidentally connected counterparts. Our results demonstrate positive effects of ICT infrastructure beyond political and economic centers, highlighting the broader impact of early connectivity.

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

2. Data

We combine data on economic development and internet infrastructure at the level of towns in SSA.[12] We start by describing the data sources of our main variables of interest and how they are constructed. Further variables and data sources are described later when they are used or in Appendix A.1. Summary statistics are reported in Appendix Table D.1.

2.1.1. Internet infrastructure

We measure internet availability over time at the town level by combining two data sources. Information on within-country internet access originates from *Africa Bandwidth Maps*, a database maintained by Hamilton Research (2024) and sourced directly from network operators. The database contains a comprehensive record of access points and their exact

[12] We define SSA 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 an economically more developed country due to a lack of comparability.

geolocation on the African continent. An access point is a node in the national fiber-optic backbone. The data covers the period from 2009 onwards, with annual updates until 2020, i.e., this information is not sufficient to analyze internet availability in the early and mid-2000s.

Therefore, we infer the construction date of earlier constructed 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 backbone deployment projects for each SSA country to determine their construction date, going back until the late 1990s for some countries.[13] Although it is not always possible to determine the exact construction year, we are able to elicit which access points were built by the year the countrywide internet connection was established, which is sufficient information for our analysis. Countries started to roll out the national backbone before international internet connections were established in anticipation of them. Appendix Figure E.1 maps all 2,734 access points and their construction years.[14] Generally, the rollout follows pre-existing infrastructure, such as major roads, railroads, or oil pipelines. We provide a brief overview of each country's rollout of the national backbone in Appendix Table D.2. Appendix B.1 details a country example as well as further background information on national backbone rollouts in SSA.

From the access points, internet users in the surrounding area are reached by local 'last mile' infrastructure. Until the 2010s and the increasing use of smartphones, users in SSA predominantly accessed the internet via cybercafés (Southwood, 2022; Williams et al., 2012). 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). The predominant access mode through cybercafés at the time did not require individual hardware adoption, and the 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). They were not only used for communication and entertainment but also for professional purposes, such as maintaining business contacts and managing the delivery of goods and supplies (Mbarika et al., 2004; Gitta and Ikoja-Odongo, 2003). We provide further background on last-mile transmission technologies and cybercafés in SSA in Appendix B.2.

[13] Documentation of our review of deployment projects, including a source register, is provided in Appendix Table F.15.

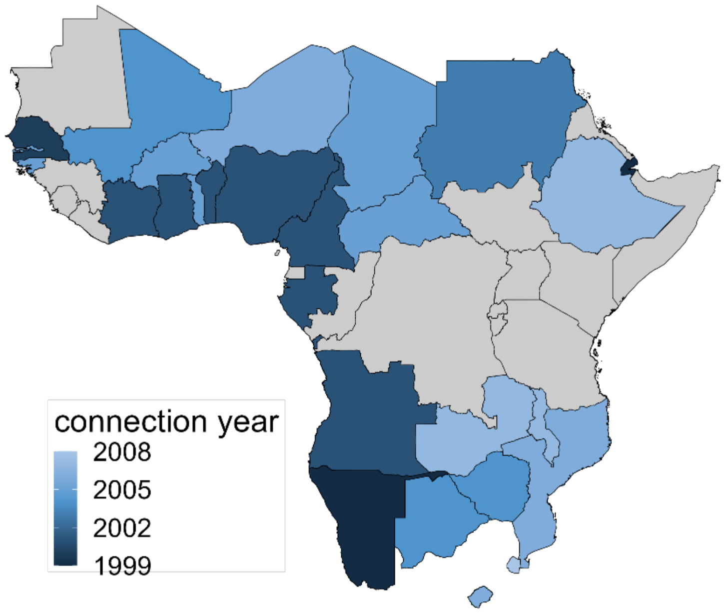
[14] About half of them were constructed in 2013 or later, and larger cities are typically served by more than one access point, usually for bandwidth reasons. This implies that, for example, in 2019, although 182 new access points were constructed, only 65 cities and towns were first connected. In total, around 1,867 cities and towns are within reach of an access point in 2020, the most recent year of our data.

Our second data source is the *Submarine Cable Map* by TeleGeography (2024), a comprehensive collection of information on global submarine cables (SMCs). SMCs are fiber-optic cables for large-scale international data transmission and form the backbone of the international internet infrastructure. SMC construction typically is a joint effort of governments, private investors, and multinational organizations (Williams, 2010). This makes it impossible for a single country to determine its SMC's arrival year. From 1999 onward, the first wave of internet-enabled SMCs brought internet connection at a noticeable scale to SSA. The largest first-wave SMC was SAT-3, which started operating in 2001 and featured landing points in nine West African countries.[15]

For our empirical analysis, we use the date on which the first-wave SMC starts operating, the so-called *ready-for-service* date, as well as information on the geolocation of the landing point in each country from the *Submarine Cable Map*. This date marks the year in which the internet connection was established. This *international* connection is crucial 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 (Chavula et al., 2015). 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. For countries that established their international internet connection through a neighboring country (mostly, but not exclusively, landlocked countries), the date at which a border access point was established marks the connection year. Figure 1 maps the connection year for each country.

[15] 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. The first large SMC connecting several East African countries was the Eastern Africa Submarine System (EASSy), which started operating only in 2010. Before, only single countries were connected, such as Djibouti through SeaMeWe-3, which connected Northern and Western Europe with Eastern Asia and Australia, in 1999, and Sudan through Saudi Arabia-Sudan-1 (SAS-1) in 2003.

Figure 1: Overview of countrywide connection years



Notes: The figure maps the SSA countries and their countrywide connection years. Blue coloring indicates the 27 countries that were connected with first-wave SMCs, with darker blues indicating earlier connection years. Connection years are also listed in Table D.3. Gray coloring indicates SSA countries that were first connected to the internet with second-wave SMCs.

Before the construction of SMCs, internet availability in SSA was very limited, slow, and prohibitively expensive (LeBlanc and Shrum, 2017; Williams, 2010). Technologies used prior to the first SMCs were either satellite- (e.g., VSAT) or telephony-based via narrowband dial-up modems (Williams, 2010). However, telephony cables are unavailable in the vast majority of SSA. While being largely unconstrained by geography and local infrastructure, satellite connection is extremely costly and allows only for narrow bandwidths. Consequently, national backbone access, in combination with the first wave of SMCs, constitutes the first viable and affordable way to go online for the vast majority of people in SSA (LeBlanc and Shrum, 2017). International bandwidth constraints that previously kept prices high relaxed considerably. SMCs of the first wave provided capacities for internet at basic speeds, i.e., connections featuring around 0.5 to 2Mbps (Hjort and Poulsen, 2019; Agyeman, 2007).[16] Usage increased drastically, starting from as low as 0.2 million users in 1998 to reaching 3.2 million by 2002 (Southwood, 2022).

[16] Between 2009 and 2012, these SMCs were proceeded by the next wave of SMCs with much higher capacities enabling higher-speed internet connections. Appendix Table D.3 reports the country-specific 'speed upgrade' year for all SSA countries being connected with basic speeds, i.e., before 2009.

2.2. Local economic development

For SSA countries, comprehensive sub-national or even city-level records of economic activity are lacking, especially as annual panel data. Therefore, we use nighttime light (NTL) emissions as a proxy for economic activity. NTL satellite data is available worldwide from 1992 until 2013 from the US Air Force *Defense Meteorological Satellite Program*'s *Operational Linescan System* (*DMSP-OLS*). These instruments measure NTL intensity on an integer scale from 0 to 63 with pixels covering 30 arc-second grid cells, an area of 0.86 square kilometers at the equator. The remote sensing literature acknowledges the usefulness of NTL data to measure economic activity (Levin et al., 2020; Levin and Duke, 2012), but emphasizes the importance of correcting *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 (Gibson et al., 2021). We use the harmonized version of the annual *DMSP-OLS* composites from Li et al. (2020), who extract only NTL emitted by human settlements by excluding 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, allowing also for annual NTL emission measurements on the same pixel size after 2013.[17]

NTL data is an established proxy for local economic development (e.g., Bluhm and McCord, 2022; Asher et al., 2021), especially where official statistics are lacking or unreliable (Nordhaus and Chen, 2015; Henderson et al., 2012; Chen and Nordhaus, 2011). 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). While Henderson et al. (2012) demonstrate the (linear) relationship between GDP growth and NTL growth at the country level, many studies validate that this also holds at the sub-national, grid, or city level (e.g., Bluhm et al., 2021; Baum-Snow et al., 2020; Henderson et al., 2018; Campante and Yanagizawa-Drott, 2018; Storeygard, 2016; Chen and Nordhaus, 2011). 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) show NTLs tend to slightly overestimate economic growth in large urban areas and underestimate growth in rural areas. Other concerns regarding NTL data, like top-coding and

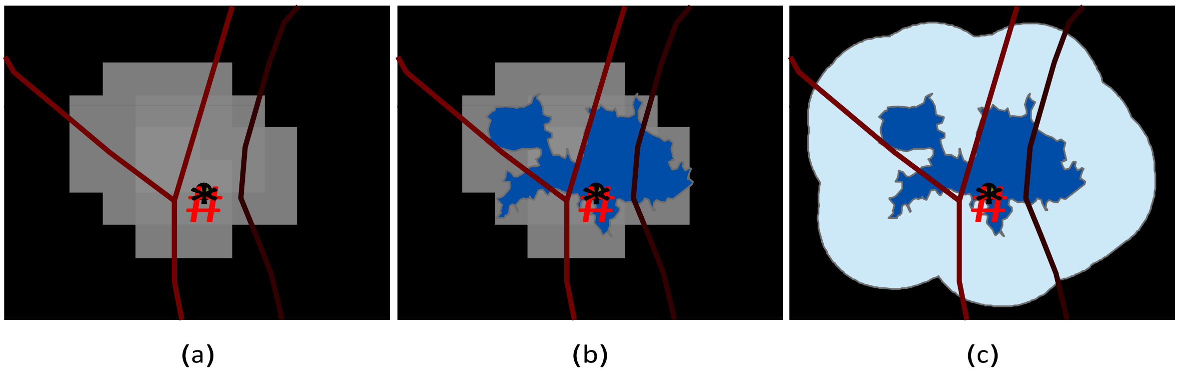
[17] *Visible Infrared Imaging Radiometer Suite* (*VIIRS*) followed the *DMSP-OLS* and is available from April 2012 onward, on a monthly basis, and has higher granularity. However, the *DMSP-OLS* until 2013 is sufficient for most specifications. Therefore, we also show results using the original *DMSP-OLS* stable and average NTL data for robustness in Appendix Table C.11.

blurring, are concentrated in cities and metropolitan areas (e.g., Bluhm and Krause, 2022; Gibson et al., 2021). NTL data, therefore, is especially well-suited for our analysis, targeting mid-sized towns in remote areas of SSA.[18]

The key advantage of NTL data is its spatial granularity. To measure local economic development at the town level, we map NTL data to human settlements using built-up areas from *Africapolis* (OECD/SWAC, 2024). This database contains the geographic delineation of 7,720 African 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 spatial information on the agglomeration landscape in Africa.[19]

Figure 2 shows a typical town for our sample: Dassa-Zoumè in Benin (19,159 inhabitants in 2000, according to *Africapolis* estimates). The gray pixels in Panel (a) show Dassa-Zoumè's NTL emission in 2004. They can clearly be attributed to the town, with lighter gray pixels indicating stronger NTL emissions. Roads going through Dassa-Zoumè are depicted as red lines and railroads in dark red. The red triangle indicates an access point. In Panel (b), we add the respective *Africapolis* built-up area. NTLs emitted by human settlements blur out to adjacent pixels, so NTLs extend beyond the towns' actual geographic footprint. This phenomenon is known as 'blurring' or 'overglow' (Abrahams et al., 2018). We account for this blurring by extending the built-up area by a buffer area with a 2-kilometer radius as illustrated in Panel (c).[20]

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



Notes: Panels (a) through (c) show a data example for Dassa-Zoumè, Benin, in 2004. Panel (a) depicts NTL emissions for the year 2004, three years after the SMC connection year of Benin. NTL intensity is shown by lighter gray rectangles. The triangle

[18] For robustness, we also show the result using top-coding adjusted NTL data (Bluhm and Krause, 2022) in Appendix Table C.11.

[19] *Africapolis* data contains information on the population of each agglomeration for the years 1950, 1960, 1970, 1980, 1990, 2000, 2010, 2015. The median size of an *Africapolis* agglomeration in 2015 is 21,136 inhabitants, and around 90 percent of towns feature less than 93,000 inhabitants. In 2000, agglomerations were considerably smaller, with a median population of 11,000, and about 90 percent of agglomerations were inhabited by less than 47,000 people.

[20] For robustness, we also show the results for a specification without a buffer and with a buffer with a 5-kilometer radius.

indicates an access point. The brighter lines represent major roads, and the darker lines represent railways. Panel (b) additionally shows Dassa-Zoumè's built-up area. Panel (c) adds a 2-kilometer buffer around the built-up area.

For each town-year observation, we measure NTL emissions by summing up the 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 NTL intensity and geographic expansion. Changes in NTL emissions over time are a measure of economic development, as shown in Storeygard (2016) and Henderson et al. (2012). 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 NTL-to-GDP elasticity of around 0.283.[21]

In addition to this composite measure, we derive two other measures from the NTLs. First, we compute a measure of growth in the intensive margin as the average NTL intensity of all pixels in a town's area as an indication of productivity growth. As this measure is sensible to newly lit pixels with a rather low value, we calculate the average NTL intensity on a fixed set of pixels and choose pixels being lit in the year before the internet connection is established. Second, we calculate the sum of all lit pixels in a town's area as a measure of population growth through spatial expansion as a measure of growth in the extensive margin. These measures provide suggestive evidence on the underlying source of economic growth.[22]

3. Empirical strategy

3.1. Model specification

Internet availability is not randomly assigned to locations. While the SMC landing point already enables internet availability, capital cities and the largest cities are often among the first to gain internet access via the national backbone. Our identification strategy aims to break the correlation between internet availability and unobserved determinants of local economic development by exploiting two sources of exogenous variation: the staggered rollout of, first, the national backbone and, second, countrywide internet connections (through SMCs). This generates quasi-random spatial and temporal variation in internet availability conditional on town and country-year fixed effects as well as (geographic) controls.

Our baseline fixed-effects panel regression to estimate the effect of early internet availability on local economic development is a difference-in-differences specification:

[21] This elasticity was replicated by Martínez (2022). However, Hu and Yao (2022) find a lower elasticity.

[22] As an alternative to the NTL-based measure of extensive-margin growth, we separately analyze changes in population density via high-resolution grids from *Gridded Population of the World*.

$$Y_{ic(i)t} = \beta_0 + \beta_1 \text{Connection}_{c(i)t} \times \text{Access}_i + \beta_2 \text{GSM}_{it} + \beta_3 (\text{X}'_i \times \text{Connection}_{c(i)t}) + \alpha_i + \alpha_{c(i)t} + \varepsilon_{ic(i)t}, \quad (1)$$

where $Y_{ic(i)t}$ is economic activity of town i in country $c(i)$ in calendar year t proxied by the logarithm of summed NTL intensities on the Africapolis built-up area with a 2-kilometer buffer. Internet is available in town i and calendar year t if two conditions hold simultaneously: country $c(i)$ has an SMC connection (potentially through a neighboring country) in calendar year t, indicated by $\text{Connection}_{c(i)t}$, and town i has access to the national backbone via an access point within a distance of 10 kilometers in the year the country gets its internet connection, indicated by Access_i.[23] The coefficient of interest is β_1. It captures the effect of early internet availability on local economic development. Note that this measure of internet 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 (Appendix B.2). Therefore, similar to other studies exploiting local internet availability, our reduced form results are best interpreted as an intention-to-treat effect (ITT).

To factor out 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 α_i. Common shocks to all towns within a country across calendar years are absorbed by country-year fixed effects $\alpha_{c(i)t}$. Note that this allows for country-specific differences across years, such as differential growth rates, and also captures variation in satellite sensor quality over time. In addition, we account for the rollout of mobile coverage by using coverage of each town with GSM signal GSM_{it}.[24] Lastly, we include a set of geographic controls X_i interacted with the connection indicator $\text{Connection}_{c(i)t}$ to allow for time-variation in the effect of geographic fundamentals potentially related to town-level growth. In our preferred specification, geographic controls include the logarithmic distance to the capital city and indicators for local availability of and logarithmic distance to the next road and railroad. For robustness, we include a specification with a larger set of geographic controls containing the logarithmic distance to the landing point and the regional capital city, indicators for local availability of and logarithmic distance to river, port, and coastline, and the logarithmic terrain

[23] According to the literature (Ngari and Petrack, 2019), as well as interviews with industry experts, this is an appropriate choice for the distance threshold. Robustness checks with alternative distance thresholds support this information (Appendix Table C.5).

[24] GSM stands for *Global System for Mobile Communications*. While not enabling mobile internet, GSM signal implies the availability of basic communication functionalities such as making calls or sending short text messages (SMS). During our observation period, GSM became available in SSA. Importantly, none of the countries in our sample started rolling out internet-enabled UMTS or LTE technology.

ruggedness index (TRI). We cluster standard errors at the level of the closest access point to account for serial correlation in the error term $\varepsilon_{ic(i)t}$.[25]

By focusing on incidentally connected towns, 'nodal cities', i.e., national and regional capital cities as well as economic centers, are excluded. Hence, we use an inconsequential treatment approach (Redding and Turner, 2015) to avoid a selection bias from economically and politically important cities. Specifically, we define economic centers as cities with more than 50,000 inhabitants in 2000 according to *Africapolis*.[26] The estimation sample contains ten SSA countries that had their first internet connection before second-wave SMCs with higher capacities landed and that rolled out the national backbone in a way that treatment and control group towns can be defined, i.e., such that some towns had an access point before the treatment year and other towns received an access point at a later point in time.[27] We estimate on a balanced panel with eleven years (five pre- and five post-treatment years; $t \in \{-5, -4, ..., 4, 5\}$). As most towns in our estimation sample are on-route between nodal cities and the treatment is determined by a fortunate location on a road chosen earlier for the national backbone rollout to follow, we mostly compare across towns on different roads.[28] To not confound our control group by compositional changes in the treatment status, we do not consider towns receiving an access point in the post-treatment period in our main specification ($t \in \{1, 2, ..., 5\}$).[29]

Simultaneous rollout of the electricity grid and the national backbone in treated but not control group towns might be a thread to isolate the effect of early internet availability. However, the fiber-optic cables introduced could not be used directly for electricity transmission, as is the case with copper cables. We restrict the sample to towns that emit NTLs in each year of observation.[30] Thus, included towns likely have an electricity connection over the whole observation period (Dugoua et al., 2018), precluding electricity grid expansion as a

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[25] We show robustness to alternative assumptions about the variance-covariance matrix in Appendix Table C.3.

[26] We select the year 2000 as most countries had their first internet connection in the early 2000s (Appendix Table D.3), and *Africapolis* provides population estimates for agglomerations only every ten years, with an additional estimate for 2015. Thus, 2010 is after the connection year for all countries, though it may be closer to the connection year than 2000 for some countries. Robustness checks regarding the population threshold choice are presented in Appendix Tables C.6 and C.7.

[27] Appendix A.2 explains the sample in detail. We show that our results are robust to not including all access points being constructed until 2020, but only taking earlier constructed ones in Appendix Table D.13.

[28] We could define the control group differently by comparing towns with a nearby access point to towns on the same road but at a greater distance from the nearest access point, and therefore, lacking internet availability. Comparing towns on the same road would reduce concerns about location-specific growth-enhancing factors, such as proximity to the capital city. However, given a specific road, the location of an access point might be endogenously influenced by the telecommunication company's economic considerations.

[29] For robustness, we will treat them as treated in a staggered treatment design in Table 4.

[30] In practice, each town should have at least one lit pixel within its built-up area or within the 2-kilometer buffer radius in each year from 1995 onward. The year 1995 is the earliest year for a country in our balanced panel as it is five years before the first connection year (Senegal in 2000).

confounding factor in our analysis.[31] Additionally, this avoids measurement error due to background noise in the data (Chen and Nordhaus, 2011). It ensures that the captured data represents an appropriate proxy for economic development at the town level but comes at the expense of losing smaller towns.

3.2. Exogeneity and identification assumptions

Our specification mimics a hypothetical situation where internet availability is randomly assigned to towns. The empirical model compares treated towns that are connected to the national backbone at the time the internet becomes available countrywide to control group towns that receive access to the national backbone at a later point in time. This exploits two types of exogenous variation. First, we use exogenous variation in internet connection at the country level from the quasi-randomness in the timing of SMC arrival. 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 with roughly equal (technically feasible) speed, irrespective of the distance to the SMC landing point. This implies that each SSA country has a countrywide treatment year. Third, SMCs serve several countries and their construction is organized and funded by various national and international players (Williams, 2010). SMCs at the time under study mostly come from Europe and feature one landing point in each SSA country they pass. Thus, single countries cannot determine their connection year, but the order in which SSA countries are connected is geographically determined.[32] This generates quasi-random variation in the timing of internet availability across SSA countries.

The second source of exogenous variation in internet availability comes from the rollout of the 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, the planning of the rollout of the national backbone typically does not consider on-route towns due to their insignificant population size compared to nodal cities (Williams et

[31] Nevertheless, we perform robustness analyses with respect to this requirement in Appendix Tables C.12 and C.13. Moreover, we use household-level data from DHS to show that dwellings in treated towns do not gain better electricity access after the countrywide internet connection.

[32] More northern countries are connected before their more southern neighbors. Western African countries were connected by a cable that arrived earlier than the cable that connected Eastern African countries. And Senegal, for instance, had an advantageous location as it was passed by a cable, Atlantis-2, connecting Europe with South America in 2000. Additionally, landlocked countries that have to establish their international internet connection through a neighboring country depend on other countries' national rollout and thus can also not determine their connection date alone.

al., 2011).[33] 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 might lie on the road between nodal cities, too, but receive their access point later as their closest nodal city might be connected to the national backbone at a later time as well.[34] 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.

The key identifying assumption for β_1 is that treated towns would have evolved similarly to control towns in the absence of treatment, i.e., if the internet had not become available. The parallel trend assumption cannot be tested directly. Its plausibility can, however, be examined by investigating pre-treatment differences in time trends between the treatment and the control group. To this end, we conduct an event study and analyze the dynamic impact of early internet availability on local economic activity by estimating:

$$Y_{ic(i)t} = \sum_{j(c(i)),\neq -1} \mu_{1j}\, t_{j(c(i))} \times \text{Access}_i + \mu_2 \text{GSM}_{it} + \mu_3 (\text{X}_i \times \text{Connection}_{c(i)t}) + \delta_i + \delta_{c(i)t} + e_{ic(i)t}, \quad (2)$$

where $t_{j(c(i))}$ indicates the year relative to the treatment year, i.e., the year when internet became available in country $c(i)$. The treatment year is defined as $j(c(i)) = 0$. We omit $j(c(i)) = -1$ as the reference point. The coefficients μ_{1j} capture the dynamic effects of early internet availability on local economic development.

A potential threat to our identification strategy is that earlier connected towns differ from control group towns in terms of an economically more favorable location. As the rollout of the national backbone is not random, we test whether observable time-invariant geographic controls correlate with the treatment status, given country fixed effects and the basic set of geographic controls. Although identification only relies on the parallel trend assumption, it adds further credibility to our identification if the treatment status cannot be predicted from these covariates. Figure 3 shows results of cross-sectional balance tests with respect to initial internet access. Access point rollout typically follows existing (transportation) infrastructure. Unsurprisingly, in Panel (a), where no controls are added, we find a negative correlation

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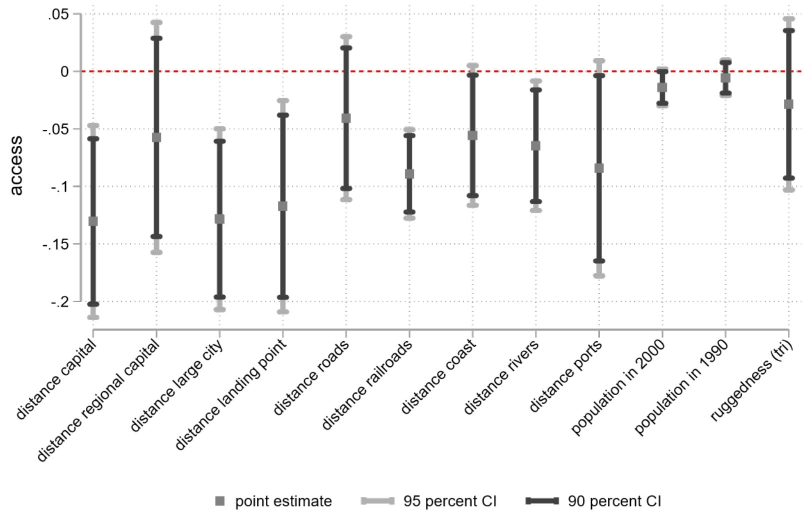
[33] Panel (a) of Appendix Figure E.2 plots the average population size in each year relative to the country connection year for towns in our sample as well as nodal cities. Nodal cities connected earlier are much larger, and the average population size declines quickly at first and more slowly after about five years post-connection. This shows that the rollout of the national backbone prioritizes larger nodal cities. Treated towns are a lot smaller in comparison.

[34] For control group towns, an alternative is that they gain access through the construction of cross-links in the national backbone, as cross-links are often added later to increase network resilience and reliability through redundancies (Appendix B.1). On average, treated towns have 14,988 and control towns 15,005 inhabitants. In addition, we show our comparison captures similar towns by analyzing the rollout of the national backbone that connects more cities and towns over time. Panel (b) of Appendix Figure E.2 focuses on treated and control towns and shows no clear association between population size and connection timing for control towns. Appendix Figure E.3 displays the density distribution for treated and control towns.

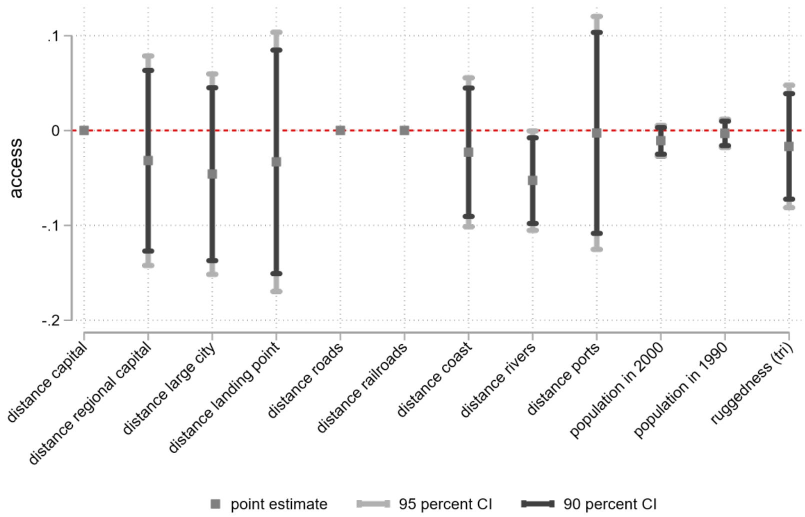
between initial access and distance to capital cities (and other nodal cities) and railroads. Our preferred specification controls for proximity to the capital city and transportation infrastructure. Therefore, we repeat this exercise, controlling for these covariates in Panel (b). Estimates for these covariates are omitted. Now, there is only a small association with the distance to the next river. All other covariates are balanced.

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 national backbone access and affects local economic development independently of internet availability. There are three main threats to identification: model misspecification, measurement error, and omitted variables. We discuss all of these in Section 4.3.

Figure 3: Timing of access to the national backbone and town characteristics



(a) base



(b) with controls

Notes: Panels (a) and (b) report OLS estimates from separate univariate regression on standardized (mean zero, unitary standard deviation) town characteristics. Estimates in Panel (a) are conditional on country fixed effects. Estimates in Panel (b) additionally control for the basic geographic characteristics: the logarithmic distance to the capital city and indicators for local availability of and logarithmic distance to the next road and railroad. The dependent variable is the access to the national backbone indicator. Confidence intervals are drawn at the 90 and 95 percent level using standard errors clustered at the access point level.

4. Results

4.1. Main effects

We use the difference-in-differences model of Equation 1 to estimate the effect of early internet availability on local economic development at the town level. The regression results are presented in Table 1. We estimate on 184 towns in ten SSA countries, with about half (48.4 percent) of the towns assigned to the treatment group, and eleven years on a balanced sample.[35] Columns (1) through (4) show results for our main outcome: NTL intensity. Column (5) presents an estimate of the intensive margin, while Column (6) gives an estimate of the extensive margin. Control variables are added gradually. Column (1) only contains town and country-year fixed effects. In Column (2), GSM mobile coverage is added. Column (3) contains the basic set of geographic controls (interacted with the connection indicator), while Column (4) contains the full set of geographic controls as described in Section 3.

In line with our expectations, we find a positive relationship between early internet availability and local economic development. Columns (1) through (4) show a positive and statistically significant effect of early internet availability on the standard NTL intensity composite measure. We translate these effects into GDP growth effects by using the elasticity between changes in NTL and GDP growth from Henderson et al. (2012) of $\epsilon_{\text{GDP, NTL}} = 0.283$.[36] 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 Column (3) of a 10.2 percent increase in NTL intensity corresponds to a 3.04 percentage point higher GDP growth in connected towns in the five years after countrywide internet connection relative to control towns connected later.

From Column (2) onwards, we add GSM mobile coverage, which is the only time-varying control we have. Its estimate is insignificant, smaller than the main effect, and its inclusion barely affects the main effect. As mobile coverage is the main alternative form of digital infrastructure in SSA at the time, this suggests that the access points and complementary last-mile infrastructure, mainly cybercafés, are, in fact, driving the main effect and not the slightly earlier rollout of mobile coverage. We discuss the role of mobile coverage in more detail later (Appendix Table D.14). Increasing model flexibility by including geographic

[35] These countries are Angola, Benin, Botswana, Ethiopia, Malawi, Mozambique, Sudan, Senegal, Zambia, and Zimbabwe. Appendix A.2 explains the sample size and how the estimation sample of countries emerges in detail.

[36] It is unclear whether the right elasticity is lower for towns in SSA as NTL intensity, on average, is lower or higher as these towns have fewer top-coded pixels Storeygard (2016).

controls in Columns (3) and (4) reduces the size of the estimates. In Column (3), our preferred specification, we control for the distance to the capital city and transportation infrastructure. The drop in the main effect from 0.13 to 0.10 indicates that a small fraction of the effect is coming from spillovers induced by proximity to the capital city, where the internet became available at the same time.[37] Nevertheless, the main effect remains sizable and statistically significant at the 1 percent level. In Column (4), we add further geographic controls. This shows that the main effect is not driven by changes in the economic benefits from geographic fundamentals after the countrywide internet connection was established.

We compare these estimates to Storeygard (2016), where cities in SSA at a similar time are investigated. Our effect in Table 1 (Column 3) is about the same size as the increase in the NTL intensity of a city near to a primate and its port in comparison to a city being 200 kilometers farther away when the oil price increased of about 72 USD. Our estimate is about a quarter of what Mensah (2021) finds for 3G mobile internet coverage.

Table 1: The effect of early internet availability on local economic development

	(1)	(2)	(3)	(4)	(5)	(6)
		NTL intensity			NTL growth source	
	composite	composite	composite	composite	intensive	extensive
Connection × Access	0.125***	0.130***	0.102***	0.0976***	0.0698***	0.0698**
	(0.0447)	(0.0455)	(0.0382)	(0.0371)	(0.0244)	(0.0334)
Mobile coverage (GSM)		0.0566	0.0504	0.0412	0.00327	0.0488
		(0.0430)	(0.0406)	(0.0396)	(0.0272)	(0.0320)
Observations	2,024	2,024	2,024	2,024	2,024	2,024
#Countries	10	10	10	10	10	10
#Towns	184	184	184	184	184	184
Share treated	0.484	0.484	0.484	0.484	0.484	0.484
R^2	0.938	0.938	0.939	0.940	0.905	0.883
Town FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×
Basic geographic controls			×	×	×	×
All geographic controls				×		
Economic growth effect	3.77	3.93	3.04	2.71	—	—

Notes: The table presents estimates based on the main specification in Equation 1. NTL intensity in Columns (1) through (4) is measured as the logarithmic sum of NTL intensities. The corresponding economic growth effect in percentage points is calculated as $[[\exp(\hat{\beta}_{connection \times access}) - 1] * \epsilon_{GDP,\, NTL}] * 100$ using the elasticity $\epsilon_{GDP,\, NTL} = 0.283$ from Henderson et al. (2012). The intensive margin in Column (5) is measured by the logarithmic average NTL intensity with fixed pixels that had an NTL emission one year before the connection year, and for the extensive margin in Column (6) as the logarithmic sum of lit, i.e., non-zero, pixels, all on the *Africapolis* built-up area with a 2-kilometer buffer. Geographic controls are constant over time and enter the model as interaction with the connection indicator. Basic geographic controls in Column (3) include the logarithmic distance to the capital city and indicators for local availability of and logarithmic distance to the next road and

[37] This specification can also be seen as a horse raise between the infrastructure variables, with a clear win for internet access.

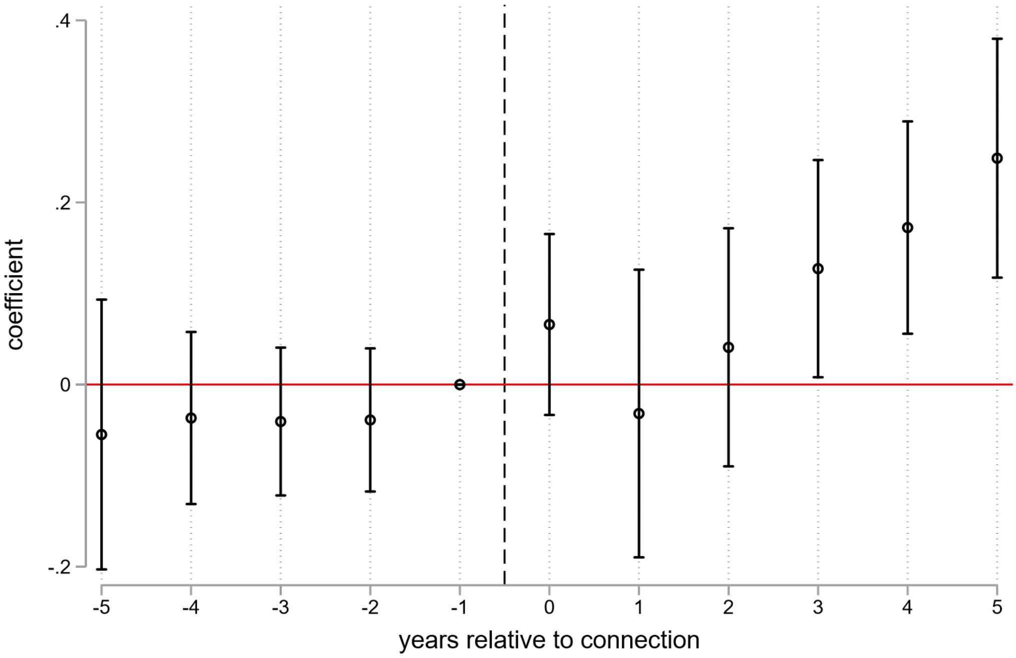
railroad. Further geographic controls in Column (4) are the logarithmic distance to the landing point and the regional capital city, indicators for local availability of and logarithmic distance to river, port, and coastline, and the logarithmic terrain ruggedness index (TRI). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Given the lack of ICT hardware, such as computers, in SSA, it is remarkable to estimate such positive effects of internet availability alone. The reduced form does not contain information on adoption rates, which are very low at the household level but increase when considering use through cybercafés. The access points we study provide the first internet connections in SSA and are established in places where there are no alternative ICTs, such as fixed-line telephony and fax machines, and might have a particularly large impact for this reason as cybercafés reduce information and communication costs drastically.

Event study estimates. To assess the plausibility of the same underlying trend assumption as well as the dynamics of the effect, we present in Figure 4 estimated event study coefficients $\hat{\mu}_{1j}$ from Equation 2. We omit the year before a country receives its first internet connection as reference point. There are no differences between connected and unconnected towns in the pre-treatment periods, depicted by insignificant estimates close to zero for all pre-treatment years.[38] About two years after a country receives its first internet connection, the trends diverge, and connected towns start to grow substantially faster compared to unconnected towns. From the third post-treatment year onwards, these dynamic estimates are statistically significant. It is intuitive that there is a lag until an economic effect materializes as adoption or behavioral adjustments take time. Our dynamic results suggest a sustained increase due to internet availability in connected towns.

[38] Specifications with different sets of covariates, corresponding to Table 1, are shown in Appendix Figures E.4, E.5, and E.6. All specifications show parallel trends in the pre-treatment periods and similar estimates in the post-treatment periods. Hence, identification does not rely on covariates. They are only included to separate the treatment effect from potential spillover effects

Figure 4: Dynamic effects of early internet availability on local economic development



Notes: The figure presents the event study coefficients based on Equation 2. The outcome is NTL intensity, measured as the logarithmic sum of NTL intensities, on the *Africapolis* built-up area with a 2-kilometer buffer. The event is defined as the year a country receives its first internet connection via an SMC (potentially through a neighboring country). Confidence intervals are drawn at the 95 percent level using standard errors clustered at the level of the closest access point. The point estimates and standard errors underlying the results are shown in Column (4) of Table 1.

Growth margin. Our composite measure combines NTL emissions as a result of both *more* lit pixels (extensive growth margin) and increased *average* NTL intensity of previously lit pixels (intensive growth margin). Both margins are suggestive of different sources of higher NTL emissions. An increasing number of lit pixels points more towards increased population through geographic expansion. In contrast, increased average NTL intensity suggests higher economic activity. We distinguish these channels by estimating separate specifications for the number of lit pixels and average NTL intensity in Columns (5) and (6) of Table 1. Results show that both margins play a role, but that the intensive margin is estimated more precisely. Some of the increase in the number of lit pixels might come from the blurring of pixels with an increased NTL intensity. The increase in the intensive margin is particularly notable, as towns in SSA typically do not accommodate population growth by increasing inhabitants per square kilometer, but through geographic expansion, with new arrivals settling at the towns' borders (Sakketa, 2023). It, thus, indicates productivity gains.

Dropping the 2-kilometer buffer and examining the original *Africapolis* built-up areas in Appendix Table D.4, we can confirm the growth in the intensive margin and effects apart from the surrounding areas (Columns 1 through 3). For the extensive margin, especially due to blurring, the 2-kilometer buffer might be too small for some towns. In Columns (4) through

(6), we re-estimate Equation 1 using a 5-kilometer buffer. A stronger effect for the extensive margin cannot be confirmed. Overall this specification estimates lower and less precise effects due to classical measurement error. Nevertheless, it confirms the importance of the intensive margin, that intensive and extensive margins contribute to the composite effect, and our choice for the 2-kilometer buffer as the main specification.

As the extensive margin measured via NTL data might be confounded by blurring, we study the extensive margin explicitly using high-resolution population grids. For each town, we compute population density estimates from the *Gridded Population of the World* data available every five years (from 2000 to 2015) and use its logarithmic values as the outcome variable in our baseline specification. Appendix Table D.5 reports the results for different sample specifications. First, we control for population density in our main specification (Column 2 of Appendix Table D.5) by computing (log-)linear imputed values for the missing years. We are aware that it might be a bad control. However, we can show that the main effect is only slightly smaller when controlling for population density and that population density has a high elasticity with NTL intensity. In Columns (3) and (4), when using population density as the outcome variable, we find positive but small point estimates, lacking statistical significance. Column (3) again uses imputed values, while Column (4) uses one data point before and one after the treatment year.[39] Estimates are very similar in both specifications. We interpret the results as pointing to an increase in productivity, i.e., higher output with (roughly) the same population, rather than a spatial redistribution of economic activity.

4.2. Individual-level evidence

So far, we have shown that towns with early internet availability experience faster growth compared to other towns in the same country where access points were constructed later. Using individual-level outcomes, we investigate employment and migration as potential key drivers of this growth. This analysis acknowledges the presence of other potential factors. Specifically, political factors could also play a role (Manacorda and Tesei, 2020; Guriev et al., 2020). Nevertheless, the relationship between increased employment and higher development appears particularly important.

Using geolocated DHS data, we analyze individual-level employment and residency duration from repeated cross-sectional surveys. The data is accessed in a harmonized version through *IPUMS DHS* (Boyle et al., 2022). We further differentiate between high-skilled, mid-

[39] As Senegal's connection year is 2000 and there are no population estimates before 2000, we define 2000 as the pre-treatment year for Senegal in this specification.

skilled, and low-skilled employment.[40] We estimate Equation 1, adding age, age squared, gender, marriage status, and education level as individual-level controls, on one pre-treatment and one post-treatment survey and take the closest survey with respect to the treatment year.[41] We join the geolocation to *Africapolis* towns. In our preferred specification, we do not restrict the towns to having NTL emissions as, unlike NTLs, DHS outcomes are not sensitive to electricity connections. Additionally, as not all towns appear in both surveys, we relax the fixed effects to the regional level (admin-2). Both relaxations are contested in robustness checks.

Employment. Table 2 shows an increase in employment of 9.3 percentage points (Column 1), with a stronger employment increase among women (Column 2). While high-skilled employment remains basically unchanged (Column 3) and decreases slightly for women (Column 4), there are some increases in mid- and low-skilled employment (Columns 5 and 7). In contrast to mid-skilled employment, where the increase is coming from men (Column 6), the low-skilled employment increase is entirely driven by women (Column 8).[42]

In addition to gender, we investigate heterogeneity across education levels (Appendix Table D.9). High education is defined as beginning with secondary education. We do not find strong differences. Nevertheless, point estimates suggest a lower overall employment and low-skilled employment effect and a slightly higher mid-skilled and particularly higher highskilled employment effect. Hence, early internet availability in this context raises employment for lower educated and a bit more for women.

[40] We use the occupation (current job) and define high-skilled jobs as occupations with employment or in 'clerical', 'clerical or sales', 'professional, technical, or managerial', 'sales', 'services', or 'skilled manual'. Low-skilled jobs are defined as self-employment or occupations in 'household, domestic, and services', 'household and domestic', 'unskilled manual', and 'other'. The remaining occupations are defined as mid-skilled: agricultural (if not stated whether it is employment or self-employment), 'armed forces', and 'skilled and unskilled manual'. The category 'not currently working' defines unemployment. Occupations grouped by skill level is following Hjort and Poulsen (2019) as far as the occupations defined by *IPUMS DHS* allow. An overview is given in Appendix Table D.6.

[41] For five SSA countries, there is a survey both before and after the treatment year. These countries are Benin (surveys in 1996 and 2001), Ethiopia (2005 and 2011), Malawi (2004 and 2010), Senegal (1997 and 2005), and Zimbabwe (1999 and 2005).

[42] Robustness checks show similar results, with a lower increase in mid-skilled employment and instead a stronger increase in low-skilled employment and a stronger (Appendix Table D.7) or lower (Appendix Table D.8) increase in female employment, depending on the specification, where Appendix Table D.7 contains more demanding town fixed effects and Appendix Table D.8 is restricted to towns with NTL emissions in all periods (as in Table 1). Both samples are, therefore, smaller.

Table 2: The effect of early internet availability on employment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Employed		High skill		Moderate skill		Low skill	
Connection × Access	0.0930***	0.0478	-0.0255	-0.00461	0.0609*	0.0874	0.0576*	-0.0349
	(0.0279)	(0.0529)	(0.0359)	(0.0579)	(0.0310)	(0.0715)	(0.0305)	(0.0374)
Connection × Access × Female		0.0488		-0.0237		-0.0546		0.127**
		(0.0585)		(0.0588)		(0.0785)		(0.0594)
Observations	8,245	8,245	8,245	8,245	8,245	8,245	8,245	8,245
#countries	5	5	5	5	5	5	5	5
#towns	81	81	81	81	81	81	81	81
Share treated	0.47	0.47	0.47	0.47	0.47	0.47	0.47	0.47
R^2	0.283	0.286	0.149	0.150	0.266	0.281	0.129	0.133
Region FE	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×

Notes: Occupation variables from DHS (0/1). Controls as in Column (3) of Table 1 plus individual level controls: age, age squared, gender, marriage status (six categories), and education level (four categories). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The effects indicate an increased demand for low-skilled workers. We can only speculate about the source. One potential explanation could be facilitated management of the delivery of goods and supplies (Mbarika et al., 2004; Gitta and Ikoja-Odongo, 2003). Women might profit from efficiency gains by producing or selling more goods. Another scenario could involve a shift from one employment tier to another: Men leaving the towns and being replaced by men who previously held low-skilled jobs, who are then subsequently replaced by women who were previously unemployed.

The effect size is in the range that Hjort and Poulsen (2019) document and higher than in their DHS sample. In contrast to them, we find higher increases in low-skilled jobs and for the lowerskilled population. For mobile internet coverage, Bahia et al. (2024) find smaller increases in employment as we do and stronger increases in wage employment instead of self-employment. These categories are comparable to high-skilled and low-skilled jobs in our study. In contrast to our study, they find a stronger effect for males. The differences to the two studies might arise from different time periods and technologies. In our study, internet availability enables only basic functionality, primarily reducing information and communication costs, with its usage largely confined to cybercafés. Furthermore, in later periods, countries may be more developed, and technologies could have varied impacts. Finally, the population composition might have changed, which might influence our results. Investigating migration next should help to better understand the employment effects.

Migration. In the DHS, respondents are asked about how long they are living at their current location. This allows us to investigate how early internet availability affects the probability of having never moved and having moved in the years since the internet became available.[43] Unfortunately, the nature of the survey allows only to investigate those who live there at the time of the survey, either as the native population or as (recent) migrants, and not those who have moved since the internet became available (potentially to the capital city or a different larger city) or their migration intentions (Adema et al., 2022).

In Table 3, we show the results and investigate again heterogeneity by gender and education. The sample decreases by one country as this question is not available for Ethiopia. For those who moved recently (Columns 1 through 3), we do not find an effect, on average (Column 1). However, we find stronger, yet insignificant, increases for males (Column 2) and better-educated individuals (Column 3) in treated towns. For non-movers (Columns 4 through 6), we find, on average, a negative effect. This indicates that more new settlers moved into the treated towns. However, it could also imply that a larger share of individuals who previously did not move have now left the treated towns. This explanation would align with findings by Adema et al. (2022), who report that mobile internet availability increases the desire and plans to emigrate. Moreover, this is plausible as individuals might relocate either to larger cities or to towns with internet access. Therefore, in treated towns, there might be more migration towards larger cities, but treated towns also become more desired destinations. We find less gender heterogeneity and a stronger effect for better-educated individuals.[44]

[43] We construct this variable for the pre-treatment survey covering the same time span of years that have passed between the internet connection and the post-treatment survey.

[44] Robustness checks indicate similar results (Appendix Tables D.10 and D.11).

Table 3: The effect of early internet availability on migration

	(1)	(2)	(3)	(4)	(5)	(6)
	Moved recently			Non-mover		
Connection × Access	-0.00685	0.0453	-0.0267	-0.122*	-0.0961	-0.116*
	(0.0267)	(0.0758)	(0.0238)	(0.0637)	(0.112)	(0.0654)
Connection × Access × Female		-0.0644			-0.0276	
		(0.0749)			(0.0898)	
Connection × Access × Education (high)			0.0692			-0.0676
			(0.0585)			(0.0924)
Observations	5,980	5,980	5,980	5,980	5,980	5,980
#Countries	4	4	4	4	4	4
#Towns	63	63	63	63	63	63
Share treated	0.428	0.428	0.428	0.428	0.428	0.428
R^2	0.108	0.108	0.109	0.131	0.131	0.133
Region FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×

Notes: Migration variables from DHS (0/1). Controls as in Table 2. Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Combining the employment and migration results, it appears that the high-skilled migrants are not creating more high-skilled jobs. Instead, they might work more in mid-skilled jobs. An alternative explanation is that they replace the original high-skilled population that might have migrated to larger cities. This would mean that even though the size of these towns remained roughly stable (Appendix Table D.5), the population composition might have changed. Appendix Table D.12 shows indicatively that migration leads to a decline in individuals with at least secondary education (in all three specifications).[45] This further indicates that treated towns suffer from high-skilled emigrants and that arriving high-skilled immigrants cannot compensate for this loss alone. Nevertheless, women and lower-skilled individuals gain jobs and the three groups together overcompensate the loss of the high-skilled emigrants.

4.3. Robustness

Model specification. Designing a control group from towns that receive an access point only after the post-treatment observation period ensures a non-contaminated control group. However, this design also leads to a five-year gap in the connection years between treated and control towns. In Table 4, we use a staggered treatment design that allows us to recover this

[45] Ethiopia is excluded to estimate on the same sample as with the migration outcomes.

gap by assigning the access point construction year as the treatment year during the analyzed post-treatment period. Note that this specification slightly changes the interpretation of the treatment, as not only the first towns receiving an access point are included in the treatment group. Instead of estimating the effect of early internet availability, we estimate the broader effect of internet availability on local economic development. In Columns (1) through (3) of Table 4, we add mobile coverage and geographic controls as in the main specification (Columns 2 and 3 of Table 1). The effect is slightly smaller (8.8 to 7.6 percentage points in comparison to 13 to 10 percentage points), and also, the decline of the estimate when controlling for mobile coverage and adding the geographic controls is smaller. A smaller effect size when adding later connected towns to the treatment group indicates that it is an advantage to be connected earlier. It also shows that they should not be added to the control group in the main specification, in line with our assumptions. In contrast to Columns (1) through (3), where the staggered treatment was applied only to the five-year post-treatment period, in Columns (4) through (6), any town that gains internet access before the speed upgrade period through second-wave SMCs is added to the treatment group. The result remains very similar.

A related concern might be that towns connected through an access point, constructed several years after the first internet connection, are not comparable to treated towns, connected via an access point built before the initial countrywide internet connection. In Appendix Table D.13, we address this concern by re-estimating our baseline specification, Equation 1, with the control group restricted to towns receiving an access point just after the five-year post-treatment period. We apply varying levels of stringency to balance the resulting reduction in sample size and improved identification. When disallowing late-connected towns in the control group to have access points built from twelve (Column 2) to two (Column 7) post-cutoff years, the effect remains relatively stable and statistically significant, albeit with a considerable reduction in sample size.

Table 4: Model specification: Staggered treatment

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)
Internet availability	0.0855***	0.0881***	0.0760***	0.0954***	0.0966***	0.0845***
	(0.0308)	(0.0311)	(0.0276)	(0.0308)	(0.0310)	(0.0281)
Observations	2,912	2,912	2,912	2,690	2,690	2,690
#Countries	10	10	10	10	10	10
#Towns	265	265	265	245	245	245
Share treated	0.642	0.642	0.642	0.669	0.669	0.669
R2	0.935	0.935	0.936	0.937	0.937	0.938
Town FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×
Mobile coverage (GSM)		×	×		×	×
Geographic controls			×			×
Post-treatment period	×	×	×			
Before speed upgrade period				×	×	×

Notes: NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Internet availability refers to an indicator taking the value one if an access point is within reach of 10 kilometers and the country is connected to the Internet via an SMC (potentially through a neighboring country) in year t or any year thereafter, and zero otherwise. Geographic controls as basic geographic controls in Column (3) of Table 1. Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Further restrictions are shown in Appendix Table C.1. These specifications include restrictions regarding the road network and the most important road, the smallest towns, the years when internet capacity was increased due to second-wave SMCs, and ethnic favoritism. Moreover, we show robustness to alternative assumptions about the variance-covariance matrix in Appendix Table C.3. In Appendix Table C.4, we use different specifications of the distance to the capital city. Besides the logarithmic distance, we re-estimate Equation 1 using the linear, quadratic, and cubic distance.

In Table 5, we estimate heterogeneous effects for towns located within 10, 10–25, and 25– 50 kilometers of an access point in the country's connection year, respectively. The estimates are relative to the omitted category: no access point within 50 kilometers in the country's connection year. As before, we add mobile coverage and the geographic controls in Columns (2) and (3). We estimate these specifications on the original sample. In Column (4), we add all towns that have an access point within 50 kilometers by 2020. This adds 45 additional towns to the sample. The results show that the effect is present for towns within 10 kilometers of an access point and that the estimate is about 3 percentage points larger in comparison to Table 1 (Columns 1 through 3). For towns 10–25 kilometers and 25–50 kilometers of an access point, the estimates decrease and lack statistical significance. For these imprecisely estimated positive point estimates, we cannot distinguish between the direct effects of the access point and spillover effects from the towns within 10 kilometers.

Table 5: Model specification: Effects on the wider surrounding area

NTL intensity	(1)	(2)	(3)	(4)
Connection × Access point ∈ (0km, 10km]	0.154***	0.162***	0.136**	0.124**
	(0.0538)	(0.0554)	(0.0528)	(0.0609)
Connection × Access point ∈ (10km, 25km]	0.0809	0.0854	0.0705	0.110
	(0.0774)	(0.0782)	(0.0674)	(0.0705)
Connection × Access point ∈ (25km, 50km]	0.0589	0.0696	0.0610	0.0853
	(0.0554)	(0.0558)	(0.0550)	(0.0605)
Observations	2,024	2,024	2,024	2,519
#Countries	10	10	10	10
#Towns	184	184	184	229
Share treated	0.484	0.484	0.484	0.389
$R2$	0.938	0.938	0.939	0.927
Town FE	×	×	×	×
Country × Year FE	×	×	×	×
Mobile coverage (GSM)		×	×	×
Geographic controls			×	×
Restriction	10km	10km	10km	50km

Notes: NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Geographic controls as basic geographic controls in Column (3) of Table 1. Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Measurement. Measurement is a key challenge in our setting. Therefore, we conduct a battery of robustness checks to account for the measurement choices implicit in our preferred specification. Importantly, we vary our choice regarding the required distance to an access point (Appendix Table C.5), the population threshold for nodal cities (Appendix Tables C.6 and C.7), and the distance threshold for nodal cities (Appendix Table C.8) and the capital city specifically (Appendix Table C.9). Furthermore, we use other sources of NTLs (Appendix Table C.11), e.g., from Bluhm and Krause (2022), and re-estimate our baseline model on a larger sample, relaxing our requirement for town-level NTL emission every year (Appendix Tables C.12 and C.13). All robustness checks are extensively discussed in the dedicated Appendix C. They demonstrate the robustness of the results with respect to measurement choices.

Omitted variables. Factors affecting the outcome and being correlated with the treatment are a threat to identification. In our context, parallel infrastructure rollout could be a potential concern. Other infrastructure that boosts local economic activity and is built in treatment but not in control group towns at the time of internet arrival might confound our estimates. Unfortunately, aside from mobile coverage, time-varying local infrastructure data are unavailable.[46] Therefore, we first account for time lags in improved mobile connectivity as potential omitted variables affecting economic activity (Appendix Table D.14). Results show that the main effect remains robust in all specifications and that there are no large differences in the lagged controls besides lag 2, where the point estimate drops. Then, we resort to alternative ways to assess the robustness with respect to other growth-enhancing infrastructures aside from mobile connectivity.

Electricity is often found growth-enhancing in developing countries (e.g., Lee et al., 2020; Rud, 2012). Consequently, simultaneous rollout of the electricity grid in treated but not control towns might be a thread to isolate the effect of early internet availability. The stable NTL emission of towns in our sample suggests electricity availability in the whole period (Dugoua et al., 2018). Nevertheless, to empirically test for spatial *and* temporal simultaneity, we draw again on georeferenced DHS, using from the household sample the question of whether the dwelling has electricity. We add household controls for the gender of the household head, her age and age squared, the number of household members, and the number of children under five years old in the household in even columns of Table 6. Columns (1) and (2) estimate on the largest possible sample without NTL emission restrictions and fixed effects at the regional level (admin-2). Unprecisely estimated *negative* coefficients are found. Columns (3) and (4) contain stricter town fixed effects. Estimates are very close to zero. Columns (5) and (6) again have region fixed effects but use only towns from our preferred specification (Table 1). Estimates are again very close to zero. Hence, the results in Table 6 provide no indication of an overlap in the rollout of the electricity grid and access points.

[46] Jedwab and Storeygard (2019) provide decadal data on improved roads. However, changes in the road network are minimal in our sample.

Table 6: Omitted variables: Electricity

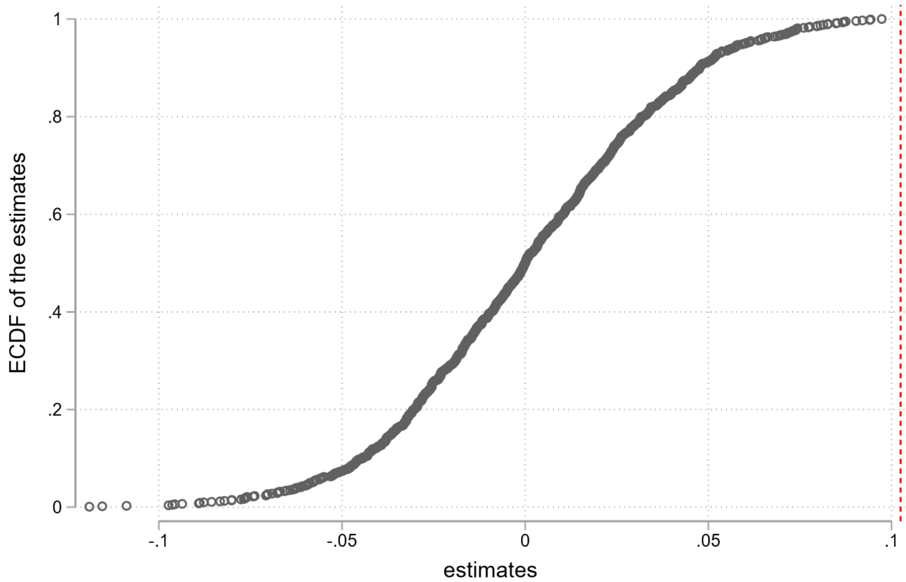
Electricity	(1)	(2)	(3)	(4)	(5)	(6)
Connection × Access	-0.0489	-0.0357	-0.0173	0.00540	-0.00138	0.00251
	(0.0578)	(0.0557)	(0.0555)	(0.0528)	(0.0850)	(0.0805)
Observations	28,451	28,440	24,045	24,034	17,444	17,440
#Countries	5	5	5	5	5	5
#Towns	81	81	56	56	46	46
Share treated	0.465	0.465	0.470	0.470	0.438	0.438
R^2	0.437	0.463	0.464	0.491	0.425	0.454
Region FE	×	×			×	×
Town FE			×	×		
Country × Year FE	×	×	×	×	×	×
No NTL restriction	×	×	×	×		
Household controls		×		×		×

Notes: Electricity at the dwelling from DHS (0/1). Controls as in Table 1 (Column 3) plus household level controls: gender of the household head, age and age squared of the household head, number of household members, and number of children under five years old in the household. Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Identification concerns regarding the simultaneous rollout of other infrastructure are warranted only if they affect economic development in treated but not control group towns at the same time as the internet becomes available in a country. 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 the rollout of the national backbone and the timing of the countrywide internet connection. For the first placebo, we randomly permutate treatment status across towns *within* countries while maintaining each country's connection year. We then follow Chetty et al. (2009) and re-estimate our preferred specification on 999 permutations. Figure 5 plots the estimated placebo coefficients against their empirical CDF. The vertical line indicates the coefficient of our preferred (true) specification (Column 3 of Table 1). None of the placebo coefficients is larger, increasing the evidence that the estimated effect is statistically significant, at least at the 1 percent level. Similarly, we conduct a second placebo exercise randomly allocating the countrywide connection years (Appendix Figure E.7). This is less straightforward because only earlier connection years are assigned and we are limited in the pre-treatment periods by the NTL data. Therefore, we allow for NTL emissions starting two years earlier (from 1993). Only three placebo coefficients are larger, increasing the evidence that the estimated effect is statistically significant at the 1 percent level.

Moreover, the placebo tests show that the captured effect indeed originates from early internet availability.

Figure 5: Distribution of access placebo estimates



Notes: The figure depicts the empirical cumulative distribution function of the main effect's estimates for 999 permutations of our baseline specification Table 1 (Column 3) with randomly assigned treatment status. The vertical line represents the true estimate.

5 Conclusion

Digital infrastructure is a key precondition to harvesting digital dividends from internet availability. Apart from major cities, remoteness and low population density make infrastructure provision in many areas of SSA particularly costly. At the same time, it is unclear if mid-sized towns in remote areas are also able to reap high benefits from internet availability. In this study, we exploit the unique setting when the internet first became available in SSA with the arrival of SMCs during the early and mid-2000s. We show that even internet at basic speeds, predominantly accessed in community-based cybercafés, significantly improves the economic development of remote towns.

We assess the effect of early internet availability on local economic development using a difference-in-difference estimation that exploits the rollout of the national backbone to define treatment and control group towns. Our quasi-experimental comparison relies on incidentally connected towns at the time of countrywide internet connection. Together with plausibly exogenous variation in the timing of first-wave SMC arrivals, this allows us to estimate effects of early internet availability. In this comparison, we track the economic activity of each town by using NTL intensity as a proxy.

We find that the early internet access of remote towns in SSA, on average, leads to an increase in their NTL intensity of about 10 percent, relative to similar towns not yet having internet access. This translates into about 3 percentage points higher growth in terms of GDP. Moreover, we decompose NTL emissions into an increase in the number of lit pixels (extensive margin) and in average NTL intensity of previous lit pixels (intensive margin), and together with an assessment of changes in population, the results indicate an increase in per capita productivity in connected towns rather than a spatial redistribution of economic activity. Using individual-level geocoded DHS, we find employment effects of early internet availability of 9.3 percentage points, slightly stronger in low-skilled employment and for women. Treated towns seem to become more attractive destinations, especially for men and higher educated individuals.

Our findings have relevant implications for policymakers. Importantly, internet infrastructure drives economic development 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. Moreover, our findings point to economic effects even with internet availability at basic speeds and through a low-cost local access mode that does not require high investments in 'last mile' infrastructure.

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Online Appendix
Digital Infrastructure and Local Economic Development: Early Internet in Sub-Saharan Africa by Moritz Goldbeck and Valentin Lindlacher

Appendix A. Supplementary data and data procesing

Appendix A.1. Supplementary data

To consider the simultaneous rollout of other digital infrastructure, we draw on mobile coverage data from Collins Bartholomew (2024), which started providing data from 1999 onwards annually. Their *Mobile Coverage Maps* provide information on the availability of mobile coverage and differentiate between the cellular technologies GSM (2G), UMTS (3G), and LTE (4G). We compute, for each town and year in our sample, the share of its area covered with GSM signal.[47]

We further tap time-varying geographic data on local population density from *Gridded Population of the World* provided by the *NASA Socioeconomic Data and Applications Center* (Center for International Earth Science Information Network (CIESIN), Columbia University, 2016). *Gridded Population of the World* data models the distribution of human population counts and densities on a continuous global raster surface. This data offers the same spatial resolution as the *DMSP-OLS* NTL data, 30 arc-second grid cells, but comes only in a time resolution of five-year intervals. We use the *UN WPP-Adjusted Population Count, v4.11*.

We obtain additional geographic information from various sources. From OpenStreetMap contributors (2024), we source information on the status as national and regional, i.e., state, capital cities, and link it to the *Africapolis* towns.[48] We obtain information on transportation infrastructure (roads and railroads) as well as on rivers and the coastline from Natural Earth (2024). Information on shipping ports originates from the *World Port Index* (National Geospatial-Intelligence Agency, 2024). We source data on terrain ruggedness in 30 arc-second resolution from Nunn and Puga (2012).[49]

Appendix A.2. Data procesing

The final estimation sample consists of ten SSA countries that (i) were connected at basic speeds and (ii) have at least one town in both the treatment and control group. We focus on first-wave SMCs bringing internet connections at basic speeds to SSA in the early and mid2000s. Therefore, we do not consider countries that were connected after 2007 for the first time when the next wave of SMCs, which allowed for much higher speeds, landed. This leaves 27 countries, which are listed in Table D.3. However, not all countries that were connected until 2007 had constructed a national backbone before the respective SMC or the connection

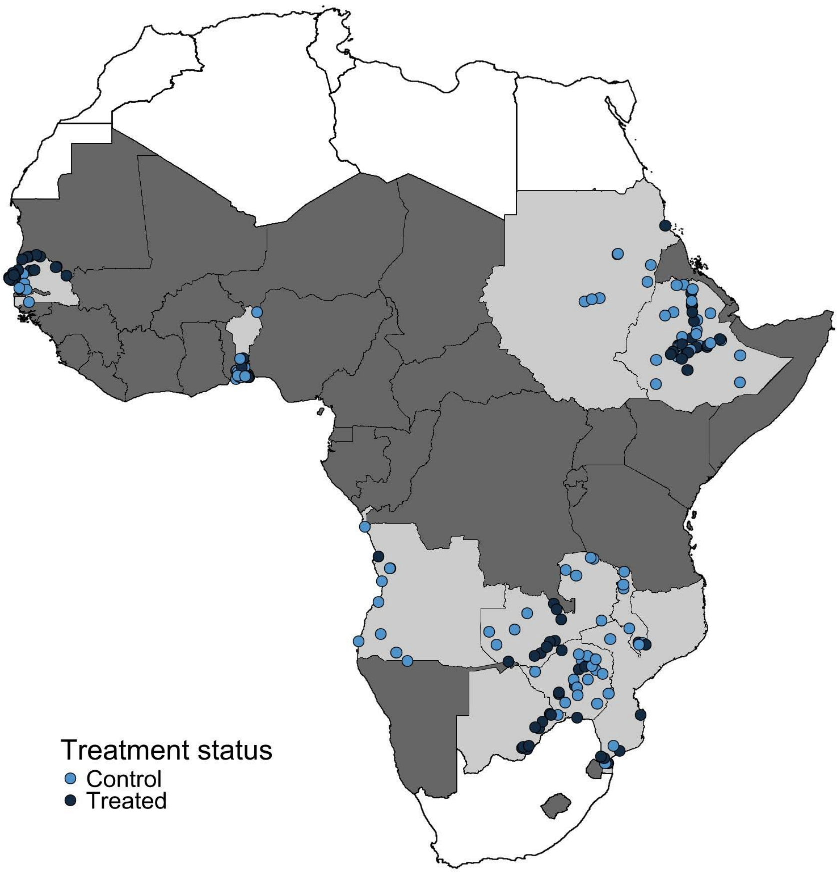
[47] Typically, these areas are either fully covered or no signal is available, i.e., the resulting value is either 0 or 1.
[48] Download via Geofabrik GmbH (2024).
[49] https://diegopuga.org/data/rugged, accessed on 06/27/2024.

through a neighboring country arrived. In this case, the treatment group is missing as there are no towns with national backbone access right after the connection was established. This reduces the number of countries in our analysis to 23.[50] Moreover, eleven countries constructed access points only in nodal cities before the countrywide internet connection was established. Therefore, there are no towns in the treatment group, and we cannot estimate on these countries. Mali and Togo are dropped as there are no towns in the control group that fulfill the NTL emission criterion. Finally, we cannot consider Namibia in our analysis because it did not construct further access points after getting the internet connection. Therefore, we are unable to define a control group. This leaves ten countries for our analysis.

Our analysis is focused on mid-sized towns. We identify 549 agglomerations in the ten SSA countries emitting NTLs each year from 1995 onwards. Of these, 145 towns (26.4 percent) are still unconnected, i.e., without an access point, in 2020. During the post-treatment period (until $t = 5$), 137 towns (25.0 percent) receive access to the national backbone and are excluded from our main specification as they may confound the control group. Of all connected agglomerations, 83 (15.1 percent) are classified as nodal cities. Thus, our main sample contains 184 towns (33.5 percent) with 89 treatment and 95 control group towns.[48] The final sample is depicted in Figure A.1.

[50] Central African Republic has not yet constructed a national backbone infrastructure by 2020. In Lesotho, the access points were established in 2009, three years after being connected through South Africa. In Djibouti, the first access points were established in 2007, which is eight years after the first SMC connection. Nigeria established its first access points in 2003, which is two years after the arrival of the first SMC (Hamilton Research, 2024). [48]This corresponds to 12.3 percent of all *Africapolis* agglomerations in the ten studied countries.

Figure A.1: Overview of the estimation sample



Notes: The figure maps the countries in our main sample (brighter gray) and the towns in the treatment and control group as dots.

Appendix B. Supplemantary information

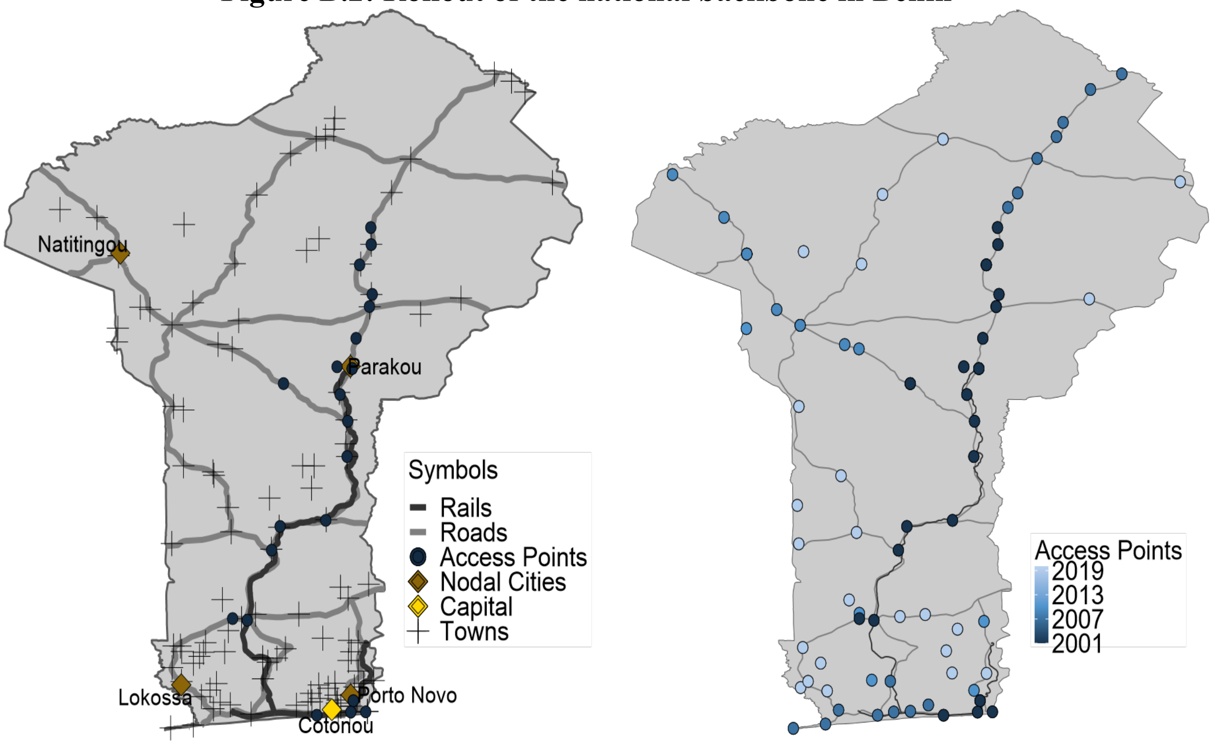
Appendix B.1. Country example: Benin

To understand the rollout of the national backbones 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 45Mbps (Chabossou, 2007). The rollout of the national backbone was planned by Benin Telecoms SA, the fixed-line monopolist that 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 2Mbps at the time (Agyeman, 2007).

Infrastructure rollout. 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 city, 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-kilometer opticalfiber 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 city of the Borgou department. This connection was constructed along Benin's railway line and road network (Panel a of Figure B.2). On its way, the national backbone connected smaller, 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 northeast, and Burkina Faso, in the northwest. These connections were constructed along the road network and transformed Benin into a sub-regional digital hub interconnecting Togo, Nigeria, Burkina Faso, and Niger. Until 2001, the SMC connection year, only the first kilometers of these fiber-optic cables and access points were constructed (Panel a of Figure B.2). 2001 was the year of the most active national backbone development in Benin. Benin Telecoms SA's infrastructure investment peaked in 2001, with more than 80 billion USD. The connection to Burkina Faso and Togo was constructed through Natitingou, the capital city of the Atakora department (Panel b of Figure B.2). 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 towns were connected (Panel b of Figure B.2). 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.). Internet was mainly accessed at cybercafés (21 percent) or at the workplace (2.2 percent), while internet at home remained expensive (Ahoyo, 2006). The number of cybercafés grew exponentially with the internet infrastructure rollout in Benin and reached several thousand. 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.

Figure B.2: Rollout of the national backbone in Benin



(a) Access points, 2001 (b) All access points

Notes: The figure outlines the rollout of access points in Benin. Panel (a) depicts the capital city, all nodal cities, all towns, and the access points that were constructed until 2001, Benin's connection year. Panel (b) depicts all access points and their respective construction years. Railroads and roads are shown in both panels.

Appendix B.2. Cybercafés, 'last mile' technologies, and internet usage

Internet in SSA countries before the era of smartphones was largely accessed through cybercafés (Southwood, 2022; LeBlanc and Shrum, 2017; Osho and Adepoju, 2016), especially in the rural areas (Williams et al., 2012). Cybercafés in SSA were community-based internet centers typically in the form of small shops or rooms with one or two computers with internet access (LeBlanc and Shrum, 2017; Mbarika et al., 2004), though larger cybercafés existed in cities (LeBlanc and Shrum, 2017). 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 connections and were limited and prohibitively expensive. Dial-up 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, the average costs of a dial-up internet account for 20 hours a month in Africa were prohibitively expensive for most households with around 68 USD per month (Mbarika et al., 2004). Internet connection via satellite (e.g., Very Small Aperture 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).

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 0.5–2Mbps 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 are communication via e-mail (89 percent), research (32 percent), entertainment (30 percent), education (27 percent), or sports and news (24 percent); 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 smallscale 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 SSA 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 (Olofinlua, 2015). Initially, internet access on personal devices remained much more expensive compared to cybercafés (LeBlanc and Shrum, 2017). However, with telecom companies starting to offer mobile-browsing packages and increasing adoption of internetenabled mobile phones, an alternative to the "long queues, overstuffed rooms, [and] lack of privacy" in cybercafés was established (Quadri, 2023). According to a survey in several African countries, mobile internet was the most commonly used form to access the internet by 2011/12 (Stork et al., 2014). But 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).

Appendix C. Additional robustness analyses

Restrictions. Though we deal with a rather small sample size, we can be more restrictive to address further concerns. Although most of the treatment and control group is connected to the transportation network via a major road, for 34 towns, a road is not passing the towns' built-up area. In Table C.1, we first estimate only on a sample of towns with road access (Column 1). The point estimate remains unchanged; however, its precision decreases. We next drop towns, which lie on a country's most important road (Column 2). This road is defined as either the road connecting the capital city with the landing point at the largest port or with the next largest city. Even though we are controlling for the distance to the capital city in all specifications (and all nodal cities in Column 4 of Table 1), towns on a particularly advantageous trade route might profit not through internet access but through other factors related with their location. We observe an unchanged effect size.[51] Next, we exclude towns that *Africapolis* reported as having zero population in the year 2000 (Column 3). One might be worried that these towns might not have been considered to receive an access point or lack further imprecise measurements. However, the share of treated towns remains similar. This specification is very demanding regarding the data: Only eight countries and 113 towns remain.[52] Nevertheless, the result remains robust. In Column (4), we remove the years after the speed upgrade with second-wave SMCs. This leaves an unbalanced sample. However, it ensures that the estimated effect does not stem from later years with higher capacities. Despite losing 143 observation-years, the effect remains unchanged.

Ethnic favoritism. A concern regarding our empirical model might be that certain ethnic groups might be favored during the rollout of the national backbone. Though the exogenous shock comes from the countrywide internet connection 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 differences over time. Using the map of ethnic boundaries by Murdock (1959) digitized by Weidmann et al. (2010), we extract for each town the ethnic group majority. We construct country-ethnic group entities instead of countries. By re-estimating Equation 1 with town and country-ethnicityyear fixed effects, treatment and control group towns are compared only within ethnic groups (and countries). If ethnic favoritism were driving the effect, the estimate in this specification would vanish. The results are shown in Column (5) of Table C.1. Naturally, sample size reduces in this more demanding specification to 132 towns in nine countries.[53] The result remains robust, showing that even when comparing treatment and control group towns in areas with the same

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[51] Agola is dropped. The estimate of the main specification without Angola is 0.0816 (SE 0.0320). In Table C.2, we re-run iterations of our baseline regression and exclude each country individually from the estimation sample. The results are robust across all specifications and remain statistically significant at least at the 5 percent level. The only notable exception is a larger *upward* deflection when Ethiopia is excluded.

[52] Angola and Malawi are dropped.

[53] Botswana is dropped. There is no control group for the largest ethnic group, despite the fact that there are towns that receive access at a later point in time. Smaller ethnic groups are not present in the treatment group.

ethnic group majority, early internet availability has a positive effect on local economic development.

Table C.1: Model specification: Robustness to further restrictions

NTL intensity	(1)	(2)	(3)	(4)	(5)
Connection × Access	0.0999**	0.0741**	0.0961**	0.108***	0.115***
	(0.0450)	(0.0348)	(0.0415)	(0.0393)	(0.0401)
Observations	1,650	1,683	1,243	1,881	1,452
#Countries	10	9	8	10	9
#Towns	150	153	113	184	132
Share treated	0.487	0.464	0.487	0.484	0.462
R2	0.933	0.910	0.956	0.939	0.926
Town FE	×	×	×	×	×
Country × Year FE	×	×	×	×	
Ethnic group-country × Year FE					×
Without	no road access	first roads			
Exclude small towns			×		
Before speed upgrade				×	

Notes: The table presents robustness checks with restrictions regarding the road network (Column 1), the most important road (Column 2), the smallest towns (Column 3), the years when internet capacity was increased due to upgraded SMCs (Column 4), and ethnic favoritism (Column 5). NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table C.2: Robustness to single country exclusions

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Connection × Access	0.102***	0.0816**	0.0945**	0.106***	0.167***	0.104***	0.109***	0.0947**	0.0901**	0.109***	0.0806**
	(0.0382)	(0.0320)	(0.0451)	(0.0388)	(0.0469)	(0.0397)	(0.0393)	(0.0387)	(0.0420)	(0.0406)	(0.0392)
Observations	2,024	1,914	1,760	1,914	1,573	1,936	1,914	1,936	1,716	1,815	1,738
#Countries	10	9	9	9	9	9	9	9	9	9	9
#Towns	184	174	160	174	143	176	174	176	156	165	158
Share treated	0.484	0.506	0.488	0.46	0.497	0.494	0.477	0.5	0.423	0.479	0.513
R2	0.939	0.941	0.943	0.933	0.945	0.939	0.938	0.940	0.940	0.937	0.931
Town FE	×	×	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×	×	×
Excluded country	none	ao	bj	bw	Et	mw	mz	sd	sn	Zm	zw

Notes: The table presents estimations excluding single countries. NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Clustering. A potential concern is that model errors may be spatially correlated within regions. If more than one town is located within 10 kilometers of an access point, this access point might serve multiple towns. Consequently, we cluster at the access point level in our preferred specification. Yet, most treatment and control group towns do not share an access point with another town in the same group. For 184 towns, there are 159 access point clusters. Moreover, access points might generate spillover effects in surrounding towns up to 50 kilometers (Table 5). To account for this, we apply a higher level of clustered standard errors in Columns (3) and (4) of Table C.3 using the administrative units of (sub-)states (admin-1 and 2). For completeness, we also cluster at the town level in Column (2). In addition, we re-estimate our baseline model using grid cell level clustering at one- (Column 5), two- (Column 6), three(Column 7), and five-degree (Column 8) grid cells, a frequently applied alternative clustering method (e.g., Hjort and Poulsen, 2019). Although the number of clusters shrinks to 31, standard errors increase only marginally.

Table C.3: Model specification: Robustness to clustering at different levels

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Connection × Access	0.102***	0.102***	0.102***	0.102**	0.102***	0.102**	0.102**	0.102**
	(0.0382)	(0.0367)	(0.0367)	(0.0409)	(0.0378)	(0.0395)	(0.0423)	(0.0425)
Observations	2,024	2,024	2,024	2,024	2,024	2,024	2,024	2,024
R^2	0.939	0.939	0.939	0.939	0.939	0.939	0.939	0.939
Town FE	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×
Cluster level	access point	town	sub-state	state	1° grid cell	2° grid cell	3° grid cell	5° grid cell
#Clusters	159	184	138	69	105	73	52	31

Notes: The table presents robustness checks to the level of clustering standard errors, based on the main specification in Equation 1. All else equal to Table 1 (Column 3). *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Distance to the capital city specifications. We want to be sure that we capture the spillovers from the capital cities. In our preferred specification, we control for the logarithmic distance to the capital city. However, it might be the case that this relationship is actually linear, quadratic, or cubic (Table C.4, Columns 2 through 4). In fact, we show that with these specifications, the estimated effect increases by about 0.1, making our preferred specification with the logarithmic distance more credible.

Table C.4: Model specification: Robustness to specifications of the capital city distance

NTL intensity	(1)	(2)	(3)	(4)
Connection × Access	0.102***	0.114***	0.115***	0.112***
	(0.0382)	(0.0407)	(0.0399)	(0.0397)
Observations	2,024	2,024	2,024	2,024
R2	0.939	0.939	0.939	0.939
Town FE	×	×	×	×
Country × Year FE	×	×	×	×
Capital city distance	log	linear	quadratic	cubic

Notes: The table presents robustness checks to the logarithmic implementation of the distance to the capital city, based on the main specification in Equation 1. NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Sample, i.e., towns, and controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Internet access. Our interview with an expert at *Africa Bandwidth Maps* suggests an average distance of 10 kilometers to access points as an appropriate proxy for internet availability, given the transmission technology used predominantly at the time.[54] 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. Nevertheless, we re-estimate our baseline model using alternative distance thresholds of 5, 7.5, 12.5, and 15 kilometers for robustness in Table C.5. Note that the distance threshold affects the sample. Specifically, when allowing for higher distances, the control group share shrinks and the sample increases. For identification, it is important that the treatment group contains only towns with internet access while the control group has no access. Too low distance thresholds potentially contaminate the control group, while too high distance thresholds might lead to wrong attributions of internet access. The results show a stable effect throughout all specifications. The slight reductions in point estimates and statistical power suggest our preferred specification is appropriate.

[54] In their own analyses of population catchment areas from 2009 onward, *Africa Bandwidth Maps* use 10, 25, and 50 kilometers distances, respectively, for different scenarios. Given the early years of the rollout of the national backbone in SSA, we opt for 10 kilometers.

Table C.5: Measurement: Robustness to access point distance thresholds

NTL intensity	(1)	(2)	(3)	(4)	(5)
Connection × Access	0.0820**	0.0976**	0.102***	0.0851**	0.0831**
	(0.0370)	(0.0404)	(0.0382)	(0.0399)	(0.0393)
Observations	1,705	1,914	2,024	2,101	2,112
#Countries	9	10	10	10	10
#Towns	155	174	184	191	192
Share treated	0.445	0.448	0.484	0.518	0.536
R^2	0.942	0.938	0.939	0.938	0.938
Town FE	×	×	×	×	×
Country × Year FE	×	×	×	×	×
Access point distance	5km	7.5km	10km	12.5km	15km

Notes: The table presents robustness checks to the distance to the closest access point to define treatment and control group, based on the main specification in Equation 1. NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Nodal cities. Classifying agglomerations into subgroups is a debated topic and depends on many factors such as the country context and development (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.[55] In Tables C.6 and C.7, we present robustness checks regarding the population threshold for nodal cities. In Table C.6, we vary the absolute threshold around our preferred definition and present alternatives ranging from 30,000 to 100,000 inhabitants. Results are very stable, with point estimates becoming slightly larger when more large towns are excluded. While the share of treated towns remains basically constant, the number of towns, unsurprisingly, increases with a higher population threshold. Yielding similarly robust results, Table C.7 presents specifications using percentile thresholds. Column (1) corresponds to a specification in which no cities are dropped due to their population size. Column (3) roughly corresponds with our main specification. Here, the largest 20 percent of towns are dropped. The effect remains when even the larger half of towns is removed (Column 6).

[55] We do not consider population density as a second criterion.

Table C.6: Measurement: Robustness to absolute population thresholds

NTL intensity	(1)	(2)	(3)	(4)	(5)
Connection × Access	0.123***	0.114***	0.102***	0.0986***	0.0940***
	(0.0413)	(0.0388)	(0.0382)	(0.0353)	(0.0352)
Observations	1,694	1,903	2,024	2,145	2,167
#Countries	10	10	10	10	10
#Towns	154	173	184	195	197
Share treated	0.481	0.468	0.484	0.487	0.492
R2	0.923	0.933	0.939	0.945	0.948
Town FE	×	×	×	×	×
Country × Year FE	×	×	×	×	×
Population threshold	30,000	40,000	50,000	75,000	100,000

Notes: The table presents robustness checks to the absolute population threshold for nodal cities, based on the main specification in Equation 1. NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table C.7: Measurement: Robustness to relative population thresholds

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)
Connection × Access	0.0886**	0.0978***	0.111***	0.117***	0.123***	0.119**
	(0.0343)	(0.0357)	(0.0380)	(0.0407)	(0.0451)	(0.0474)
Observations	2,310	2,167	1,958	1,716	1,452	1,232
Countries	10	10	10	9	9	9
Towns	210	197	178	156	132	112
Share treated	0.514	0.487	0.483	0.487	0.500	0.500
R2	0.962	0.947	0.937	0.933	0.925	0.924
Town FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×
Population threshold	1	0.9	0.8	0.7	0.6	0.5

Notes: The table presents robustness checks to the relative population threshold for nodal cities, based on the main specification in Equation 1. NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Besides the population threshold, we show robustness to excluding towns that have a nodal city within 10, 25, and 50 kilometers (Table C.8). This comes at the cost of reducing the sample to 139, 106, and 82 towns and nine to eight countries, with Angola excluded first and Malawi second. Column (1) corresponds to the main specification where nodal cities are removed, but no towns in proximity to a nodal city. The point estimates are robust across all specifications, but they lose precision due to the smaller sample size. We proceed similarly with the distance to the capital city (Table C.9), where we consider specifications in which towns up to 150 kilometers away from the capital city are excluded. We choose a larger threshold for these specifications because capital cities are generally larger and might generate spillover effects over greater distances. The sample size shrinks to 95 towns in Column (7). With a distance threshold of 25 kilometers or more, Angola is excluded (Columns 3 through 7). The results remain robust across all specifications.

Table C.8: Measurement: Robustness to nodal city distance thresholds

NTL intensity	(1)	(2)	(3)	(4)
Connection × Access	0.102***	0.0968**	0.0925**	0.0902*
	(0.0382)	(0.0389)	(0.0437)	(0.0535)
Observations	2,024	1,529	1,166	902
#Countries	10	9	8	8
#Towns	184	139	106	82
Share treated	0.484	0.46	0.434	0.451
R^2	0.939	0.941	0.947	0.947
Town FE	×	×	×	×
Country × Year FE	×	×	×	×
Nodal city distance threshold	0km	10km	25km	50km

Notes: The table presents robustness checks to the distance threshold for nodal cities, based on the main specification in Equation 1. NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table C.9: Measurement: Robustness to capital city distance thresholds

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Connection × Access	0.102***	0.112***	0.0875***	0.0898***	0.0878**	0.0818**	0.0861**
	(0.0382)	(0.0408)	(0.0318)	(0.0335)	(0.0341)	(0.0359)	(0.0380)
Observations	2,024	1,892	1,661	1,507	1,419	1,232	1,045
#Countries	10	10	9	9	9	9	9
#Towns	184	172	151	137	129	112	95
Share treated	0.484	0.453	0.47	0.453	0.45	0.446	0.421
R^2	0.939	0.940	0.939	0.940	0.935	0.944	0.952
Town FE	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×
Capital city distance threshold	0km	10km	25km	50km	75km	100km	150km

Notes: The table presents robustness checks to the distance threshold for the capital city, based on the main specification in Equation 1. NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

We conclude the robustness part on nodal cities by presenting results when step-wise removing nodal cities (Table C.10). The point estimates increase from *including* all nodal cities (Column 1) to *excluding* all nodal cities (Column 5) and remain statistically significant, at least at the 5 percent level.

Table C.10: Measurement: Robustness to step-wise removing nodal cities

NTL intensity	(1)	(2)	(3)	(4)	(5)
Connection × Access	0.0683**	0.0725**	0.0686**	0.0886**	0.102***
	(0.0308)	(0.0332)	(0.0323)	(0.0343)	(0.0382)
Observations	2,937	2,882	2,827	2,310	2,024
#Countries	10	10	10	10	10
#Towns	267	262	257	210	184
Share treated	0.539	0.531	0.521	0.514	0.484
R^2	0.971	0.967	0.961	0.962	0.939
Town FE	×	×	×	×	×
Country × Year FE	×	×	×	×	×
Without nodal cities	none	landing point	+ capital	+ regional capitals	+ large cities

Notes: The table presents robustness checks to step-wise removing nodal cities, based on the main specification in Equation 1. NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

NTL. In Table C.11, we show the robustness to other satellite data sources and procedures. Column (1) repeats the main specification. Column (2) uses NTLs adjusted for top-coding instead (Bluhm and Krause, 2022). Columns (3) and (4) are re-estimated with the original *DMSP-OLS* data using stable and average NTLs (National Oceanic and Atmospheric Administration (NOAA), 2020). In Columns (1) through (3), results are essentially the same. Column (4) shows a slightly less precisely estimated and slightly lower point estimate.

We elicit economic development of towns from changes in NTL emissions. In the main specification, we restrict the sample to towns with NTL emission in all years from 1995 onwards (the earliest year used in the pre-treatment periods). This ensures that we capture the intensive margin in NTL emissions as the electricity grid might potentially be rolled out simultaneously to the national backbone and might affect the extensive margin, i.e., the creation of towns. As this comes at the expense of sample size, we relax this restriction and conduct two types of robustness analyses. In Table C.12, we allow the sample to have missing NTL emission in up to three years at any point in time. In Columns (1) through (4), there is no other restriction, while in Columns (5) through (8), the sample is restricted to NTL emission from 1995 onwards as in the main specification (Table 1). In both cases, when allowing for more missing NTL years, the sample size increases and the share of treated towns decreases. The results remain robust, yet due to classical measurement error, point estimates get slightly smaller and are less precisely estimated with more missing NTL years. We, therefore, estimate alternative specifications with imputed values in Table C.13, which improves the statistical power of the estimates in comparison to Table C.12. We impute missing values with the mean if data is not missing in the year before *and* after the missing year. Two consecutive missing years are not imputed. The results remain robust, with slightly more towns included but slightly lower precision due to classical measurement error.

Table C.11: Measurement: Robustness to other NTL sources and procedures

	(1)	(2)	(3)	(4)
NTL intensity	Harmonized	Topcoded	Stable	Average
Connection × Access	0.102***	0.102***	0.103***	0.0896**
	(0.0382)	(0.0384)	(0.0379)	(0.0402)
Observations	2,024	2,024	2,024	2,024
R^2	0.939	0.953	0.953	0.961
Town FE	×	×	×	×
Country × Year FE	×	×	×	×

Notes: The table presents robustness checks to using other sources and procedures of NTL intensity, based on the main specification in Equation 1. NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Same towns and controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table C.12: Measurement: Robustness to ignoring missing NTL years

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Connection × Access	0.0973**	0.107***	0.0817**	0.0608	0.102***	0.0949**	0.0882**	0.0877**
	(0.0460)	(0.0391)	(0.0388)	(0.0402)	(0.0382)	(0.0401)	(0.0429)	(0.0431)
Observations	1,683	2,009	2,135	2,368	2,024	2,251	2,346	2,418
Countries	10	10	10	10	10	10	10	10
Towns	153	183	194	214	184	203	209	215
Share treated	0.503	0.47	0.464	0.472	0.484	0.448	0.435	0.428
R^2	0.943	0.938	0.938	0.933	0.939	0.931	0.929	0.924
Town FE	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×
Early-year restriction					×	×	×	×
Missing values ignored	0	1	2	3	0	1	2	3

Notes: The table presents robustness checks to missing NTL years, based on the main specification in Equation 1. NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2kilometer buffer. Controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table C.13: Measurement: Robustness to imputing missing NTL years

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Connection × Access	0.0973**	0.0973**	0.0935**	0.0935**	0.102***	0.0934**	0.0951**	0.0907**
	(0.0460)	(0.0454)	(0.0447)	(0.0447)	(0.0382)	(0.0416)	(0.0440)	(0.0439)
Observations	1,683	1,738	1,749	1,749	2,024	2,233	2,277	2,288
Countries	10	10	10	10	10	10	10	10
Towns	153	158	159	159	184	203	207	208
Share treated	0.503	0.487	0.484	0.484	0.484	0.453	0.449	0.447
R_2	0.943	0.945	0.945	0.945	0.939	0.933	0.931	0.931
Town FE	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×
Early-year restriction					×	×	×	×
Missing values imputed	0	1	2	3	0	1	2	3

Notes: The table presents robustness checks to missing NTL years, based on the main specification in Equation 1. NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2kilometer buffer. Controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix D. Tables

Table D.1: Summary statistics

	(1) Mean	(2) sd	(3) min	(4) p25	(5) p50	(6) p75	(7) Max	(8) N
Population (in 2000)	14,996.78	14,052.56	0.00	0.00	13,561	24,366	49,217	184
Number of lit pixels (in t-1)	49.01	27.53	12	31	43	60	232	184
light intensity (in t-1)	494.60	594.45	57	178	307	564	4,873	184
Average light intensity of lit pixels in 1995 (in t-1)	8.44	4.94	2.67	4.86	6.87	10.05	30.01	184
Distance to the capital [km]	245.11	222.96	6.13	78.20	183.99	360.98	1,257.73	184
Distance to the regional capital [km]	107.98	75.64	5.49	42.63	93.33	153.73	403.31	184
Distance to the next larger city (50k inhab.) [km]	80.71	79.81	5.18	22.28	56.72	111.41	462.71	184
Distance to the road network [km]	4.80	14.49	0.02	0.32	0.92	3.46	117.50	184
Distance to the railroad network [km]	74.95	119.72	0.04	1.25	11.55	103.50	564.94	184
Distance to next river [km]	68.57	74.26	0.37	16.37	51.99	97.53	511.53	184
Distance to the coastline [km]	365.33	311.62	0.31	67.01	328.37	577.99	1,163.80	184
Distance to the SMC landing point [km]	528.36	392.03	6.07	150.18	520.88	825.84	1,457.46	184
Distance to next port [km]	397.21	312.04	2.13	99.01	373.75	606.56	1,202.86	184
Mobile coverage (in t-1, GSM) [%]	53.92	49.02	0.00	0.00	96.06	100.00	100.00	184
Distance to next AP (in treatment year) [km]	105.34	201.52	0.00	0.00	12.15	91.40	999.75	184
Terrain ruggedness (log)	10.61	1.67	0.00	9.87	10.79	11.64	13.36	184
Road network access	0.82	0.39	0	1	1	1	1	184
Railroad network access	0.38	0.49	0	0	0	1	1	184
River access	0.14	0.34	0	0	0	0	1	184
Coast access	0.07	0.26	0	0	0	0	1	184
Port access	0.01	0.10	0	0	0	0	1	184

Notes: The table reports summary statistics for the estimation sample.

Table D.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 neighboring 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 southeastern border with ZAF	
Burkina Faso	BFA	SEN-MLI	2005	network is expanded focused on routes necessary for international connection and border points to further neighboring 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
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

Table continues on the next page.

Country	ISO	Via	Year	National backbone	Notes
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
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

Country	ISO	Via	Year	National backbone	Notes
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-1	2003	network expansion to all regional capitals; more dense in the east and along the Nile river; landing point at largest port	
Eswatini	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
Zambia	ZMB	EASSy	2007	extensive network expansion all over the country	state-owned electricity grid operator used preexisting powerlines to establish an unusually dense network
Zimbabwe	ZWE	ZAF	2004	network expansion covers larger cities and connections to border points	

Sources: Table F.15, Africa Bandwidth Maps, own research.

Table D.3: Overview of 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 Rep.	2005	Neighboring country		2012
Guinea-Bissau	2005	Sub-marine cable	Suro	2012
Mozambique	2006	Neighboring country		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
Eswatini	2008	Neighboring country		2009

Notes: The table reports the connection years of all SSA countries being connected before 2009.

Table D.4: Robustness to different buffer specifications

	(1)	(2)	(3)	(4)	(5)	(6)
	NTL intensity	Int. margin	Ext. margin	NTL intensity	Int. margin	Ext. margin
Connection × Access	0.0855***	0.0816***	0.0200	0.0787*	0.0568**	0.0794*
	(0.0295)	(0.0263)	(0.0131)	(0.0447)	(0.0253)	(0.0416)
Observations	1,782	1,782	1,782	2,211	2,211	2,211
#Countries	9	9	9	10	10	10
#Towns	162	162	162	201	201	201
Share treated	0.500	0.500	0.500	0.468	0.468	0.468
R^2	0.976	0.926	0.981	0.949	0.903	0.916
Town FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×
Buffer radius	0km	0km	0km	5km	5km	5km

Notes: The table presents robustness checks to removing the 2-kilometer buffer (Columns 1 through 3) and extending it to a 5-kilometer buffer (Columns 4 through 6) around the *Africapolis* built-up area. NTL intensity as in in Table 1 (Columns 1 through 4), intensive margin as in Table 1 (Column 5), and extensive margin as in Table 1 (Column 6). Controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table D.5: Population density

	(1)	(2)	(3)	(4)
	NTL intensity		Population density	
Connection × Access	0.102***	0.0854***	0.0205	0.0196
	(0.0382)	(0.0326)	(0.0186)	(0.0204)
Population density		0.830**		
		(0.332)		
Observations	2,024	2,024	2,024	368
R^2	0.939	0.941	0.999	0.999
Town FE	×	×	×	×
Country × Year FE	×	×	×	×

Notes: NTL intensity is measured as the logarithmic sum of NTL intensities, and population density is measured as the logarithmic mean of pixel-level population counts, both on the *Africapolis* built-up area with a 2-kilometer buffer. Same towns and controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table D.6: Employment summary

Occupation	N	%	Skill level
Agricultural	6,525	6.75	mid
Agricultural, employee	1,749	1.81	high
Agricultural, self-employed	2,970	3.07	low
Armed forces	20	0.02	mid
Clerical	1,750	1.81	high
Clerical or sales	1,833	1.90	high
Household and domestic	672	0.70	low
Household, domestic, and services	3,488	3.61	low
Not currently working	35,320	36.56	—
Other	585	0.61	low
Professional, technical, or managerial	4,767	4.93	high
Sales	20,758	21.49	high
Services	2,114	2.19	high
Skilled and unskilled manual	2,511	2.60	mid
Skilled manual	8,965	9.28	high
Unskilled manual	2,589	2.68	low

Notes: The table reports occupation categories from DHS and their assignment to the skill levels.

Table D.7: Employment: Robustness to town fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Employed		High skill		Moderate skill		Low skill	
Connection × Access	0.108***	0.0319	-0.0232	0.00345	0.0286	0.0688	0.103***	-0.0404
	(0.0301)	(0.0632)	(0.0497)	(0.0808)	(0.0462)	(0.0906)	(0.0338)	(0.0574)
Connection × Access × Female		0.0896		-0.0257		-0.0762		0.192**
		(0.0578)		(0.0716)		(0.0912)		(0.0752)
Observations	4,408	4,408	4,408	4,408	4,408	4,408	4,408	4,408
#Countries	5	5	5	5	5	5	5	5
#Towns	35	35	35	35	35	35	35	35
Share treated	0.394	0.394	0.394	0.394	0.394	0.394	0.394	0.394
R2	0.286	0.289	0.158	0.158	0.227	0.244	0.136	0.144
Town FE	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×

Notes: Occupation variables from DHS (0/1). Controls as in Table 2. Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table D.8: Employment: Robustness to the NTL restriction

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Employed		High skill		Moderate skill		Low skill	
Connection × Access	0.110***	0.0897	-0.0226	0.00700	0.0382	0.109	0.0941***	-0.0259
	(0.0327)	(0.0695)	(0.0474)	(0.0748)	(0.0439)	(0.0831)	(0.0325)	(0.0526)
Connection × Access × Female		0.0171		-0.0290		-0.116		0.162**
		(0.0657)		(0.0655)		(0.0821)		(0.0697)
Observations	4,914	4,914	4,914	4,914	4,914	4,914	4,914	4,914
#Countries	5	5	5	5	5	5	5	5
#Towns	46	46	46	46	46	46	46	46
Share treated	0.428	0.428	0.428	0.428	0.428	0.428	0.428	0.428
R^2	0.276	0.278	0.154	0.155	0.225	0.242	0.132	0.138
Region FE	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×

Notes: Occupation variables from DHS (0/1). Controls as in Table 2. Towns without NTL emissions in all years are dropped as in the main specification (Table 1). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table D.9: The effect of early internet availability on employment by education

	(1)	(2)	(3)	(4)
	Employed	High skill	Moderate skill	Low skill
Connection × Access	0.0994***	-0.0295	0.0556	0.0733*
	(0.0348)	(0.0401)	(0.0342)	(0.0377)
Connection × Access × Educ. (high)	-0.0286	0.0185	0.00909	-0.0562
	(0.0765)	(0.0629)	(0.0657)	(0.0457)
Observations	8,245	8,245	8,245	8,245
#Countries	5	5	5	5
#Towns	81	81	81	81
Share treated	0.47	0.47	0.47	0.47
R^2	0.284	0.149	0.267	0.130
Region FE	×	×	×	×
Country × Year FE	×	×	×	×

Notes: Occupation variables from DHS (0/1). Controls as in Table 2. Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table D.10: Migration: Robustness to town fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)
	Moved recently			Non-mover		
Connection × Access	-0.0220	0.0412	-0.0352	-0.106	-0.0842	-0.110
	(0.0267)	(0.0764)	(0.0239)	(0.0650)	(0.110)	(0.0658)
Connection × Access × Female		-0.0773			-0.0259	
		(0.0766)			(0.0836)	
Connection × Access × Education (high)			0.0488			-0.0352
			(0.0611)			(0.0930)
Observations	5,162	5,162	5,162	5,162	5,162	5,162
#Countries	4	4	4	4	4	4
#Towns	47	47	47	47	47	47
Share treated	0.405	0.405	0.405	0.405	0.405	0.405
R^2	0.114	0.114	0.114	0.134	0.135	0.136
Town FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×

Notes: Migration variables from DHS (0/1). Controls as in Table 2. Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table D.11: Migration: Robustness to the NTL restriction

	(1)	(2)	(3)	(4)	(5)	(6)
	Moved recently			Non-mover		
Connection × Access	-0.0550*	0.00428	-0.106***	-0.162*	-0.145	-0.133*
	(0.0315)	(0.0916)	(0.0273)	(0.0841)	(0.162)	(0.0774)
Connection × Access × Female		-0.0804			-0.0138	
		(0.0914)			(0.110)	
Connection × Access × Education (high)			0.154**			-0.129
			(0.0668)			(0.1000)
Observations	4,237	4,237	4,237	4,237	4,237	4,237
#Countries	4	4	4	4	4	4
#Towns	39	39	39	39	39	39
Share treated	0.439	0.439	0.439	0.439	0.439	0.439
R^2	0.115	0.117	0.117	0.126	0.128	0.127
Region FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×

Notes: Migration variables from DHS (0/1). Controls as in Table 2. Towns without NTL emissions in all years are dropped as in the main specification (Table 1). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table D.12: Education

Education (high)	(1)	(2)	(3)
Connection × Access	-0.0610***	-0.0464*	-0.0605*
	(0.0213)	(0.0240)	(0.0350)
Observations	6,170	5,292	4,406
#Countries	4	4	4
#Towns	63	47	39
Share treated	0.438	0.414	0.453
R^2	0.319	0.332	0.282
Region FE	×		×
Town FE		×	
Country × Year FE	×	×	×
NTL restriction			×

Notes: At least secondary education from DHS (0/1). Controls as in Table 2 minus education levels. Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table D.13: Model specification: Robustness to the specification of the control group

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Connection × Access	0.102***	0.0950**	0.0853*	0.0880*	0.0793*	0.117*	0.105**
	(0.0382)	(0.0420)	(0.0443)	(0.0460)	(0.0459)	(0.0609)	(0.0410)
Observations	2,024	1,925	1,650	1,452	1,419	1,133	935
#Countries	10	10	9	8	8	8	6
#Towns	184	175	150	132	129	103	85
Share treated	0.484	0.509	0.44	0.432	0.442	0.553	0.635
R^2	0.939	0.940	0.941	0.935	0.936	0.936	0.945
Town FE	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×
#Post-observation period years	All	12	10	8	6	4	2

Notes: The table presents robustness checks restricting the control group by the number of allowed postobservation period years. NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Column (3) of Table 1. Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

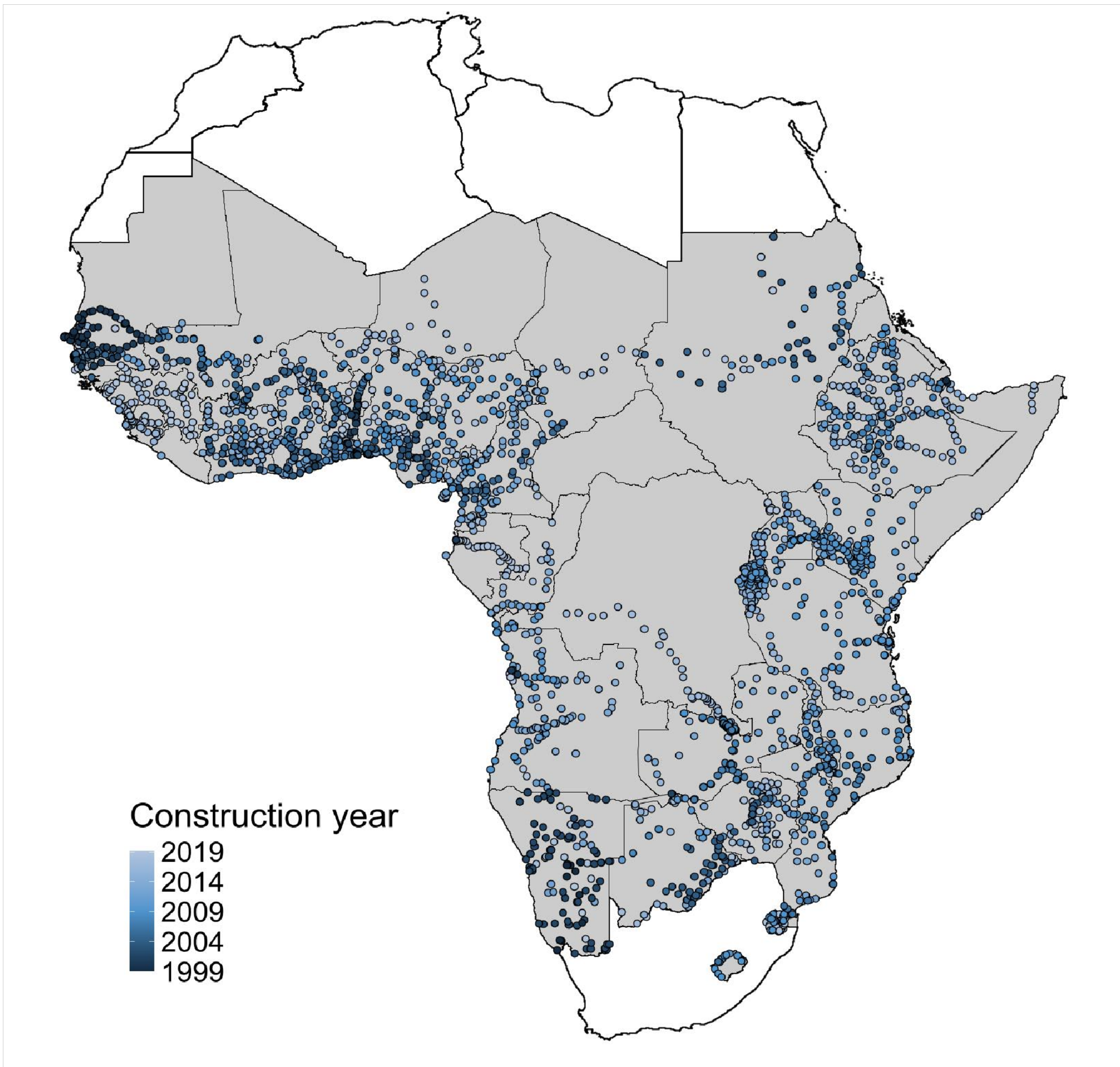
Table D.14: Omitted variables: Robustness to lagged mobile coverage

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)
Connection × Access	0.102***	0.103***	0.0983**	0.0993***	0.0975***	0.0942**
	(0.0382)	(0.0379)	(0.0383)	(0.0371)	(0.0370)	(0.0376)
Mobile coverage	0.0504					
	(0.0406)					
Mobile coverage (lag 1)		0.0683				
		(0.0430)				
Mobile coverage (lag 2)			-0.0199			
			(0.0421)			
Mobile coverage (lag 3)				0.0499		
				(0.0344)		
Mobile coverage (lag 4)					0.0584*	
					(0.0328)	
Mobile coverage (lag 5)						0.0594*
						(0.0329)
Observations	2,024	2,024	2,024	2,024	2,024	2,024
R^2	0.939	0.939	0.939	0.939	0.939	0.939
Town FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×

Notes: The table presents robustness checks with respect to the inclusion of lagged terms of the mobile coverage control. NTL intensity is measured as the logarithmic sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Same towns and geographic controls as in Table 1 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

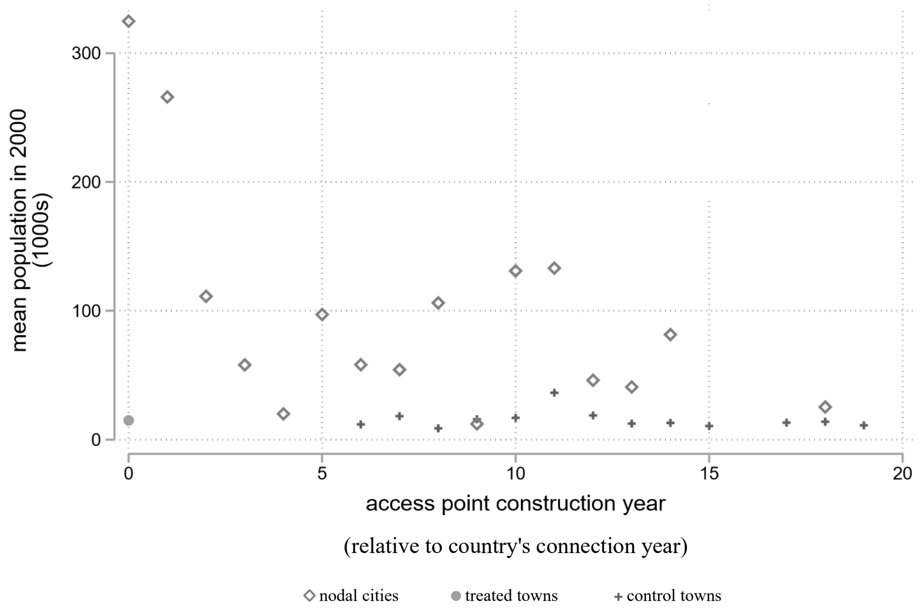
Appendix E. Figures

Figure E.1: Overview of all access points

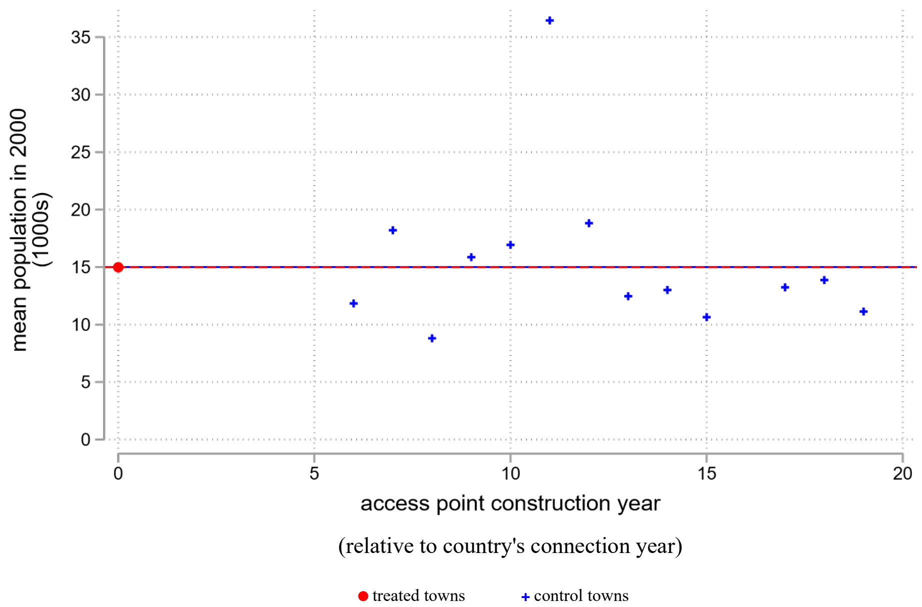


Notes: The figure maps the location of all SSA access points. Blue coloring indicates construction years, with brighter blue corresponding to later years.

Figure E.2: Population of cities and town with national backbone access over time



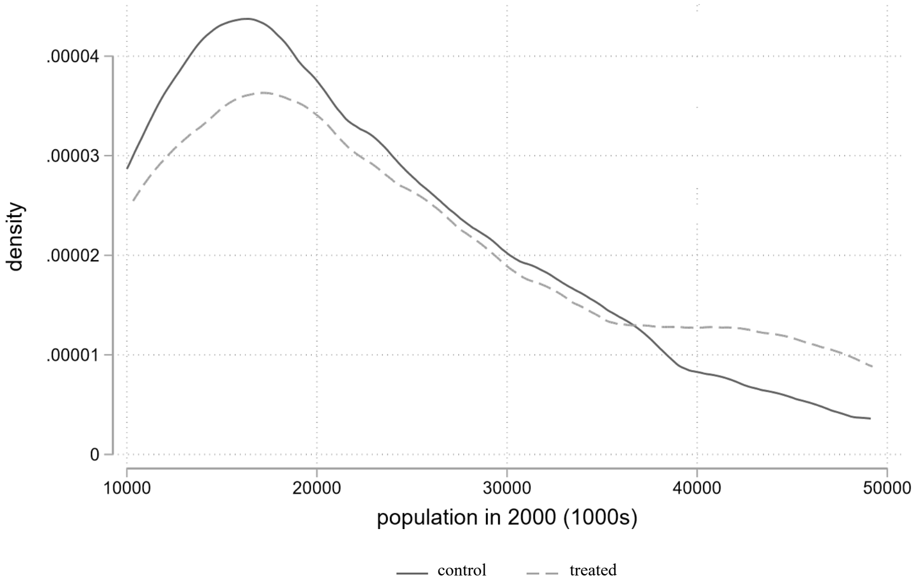
(a) with nodal cities



(b) treatment and control group towns

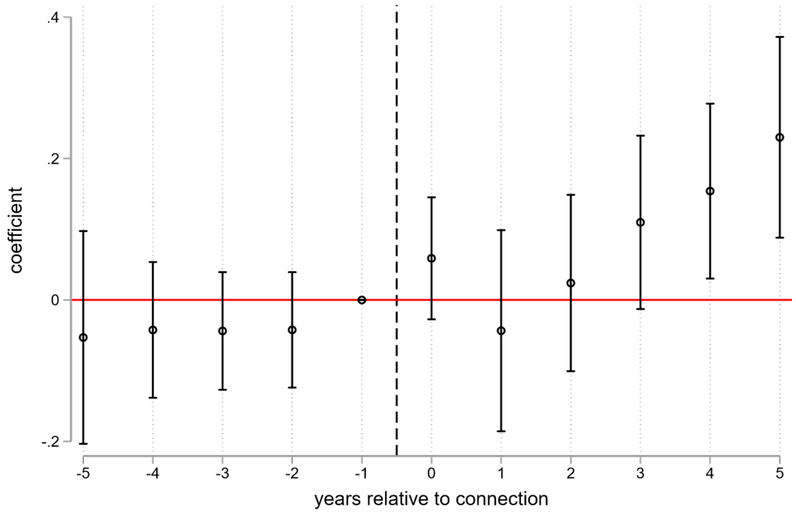
Notes: The figure depicts the average population size of cities and towns with national backbone access by year relative to the connection year. In Panel (a), the gray dot in the lower left corner represents the treated towns, while the control towns are represented by the plus symbol and the nodal cities by a diamond. For clarity, treated towns and nodal cities that were connected in earlier years than the arrival of an SMC are shown in year zero as well. In Panel (b), the treatment and control group are shown in more detail without nodal cities. Their averages are shown by horizontal lines.

Figure E.3: Population distribution



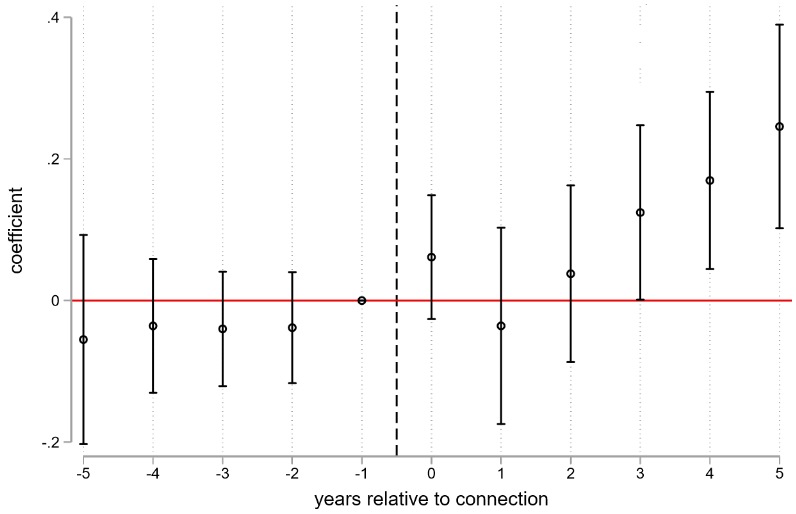
Notes: The figure plots kernel density estimates for the distribution of population size in 2000, separately for treated and control towns (restricted to a population minimum of 10,000 inhabitants).

Figure E.4: Dynamic effects of early internet availability on local economic development I



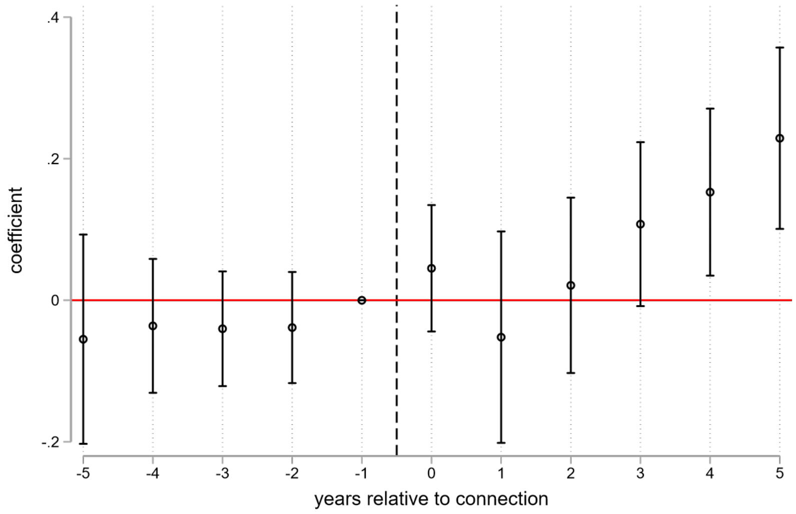
Notes: The figure presents the event study coefficients based on Equation 2 without any controls. The outcome is NTL intensity, measured as the logarithmic sum of NTL intensities, on the *Africapolis* built-up area with a 2kilometer buffer. The event is defined as the year a country receives its first internet connection via an SMC (potentially through a neighboring country). Confidence intervals are drawn at the 95 percent level using standard errors clustered at the level of the closest access point. The point estimates and standard errors underlying the results are shown in Column (1) of Table 1.

Figure E.5: Dynamic effects of early internet availability on local economic development II



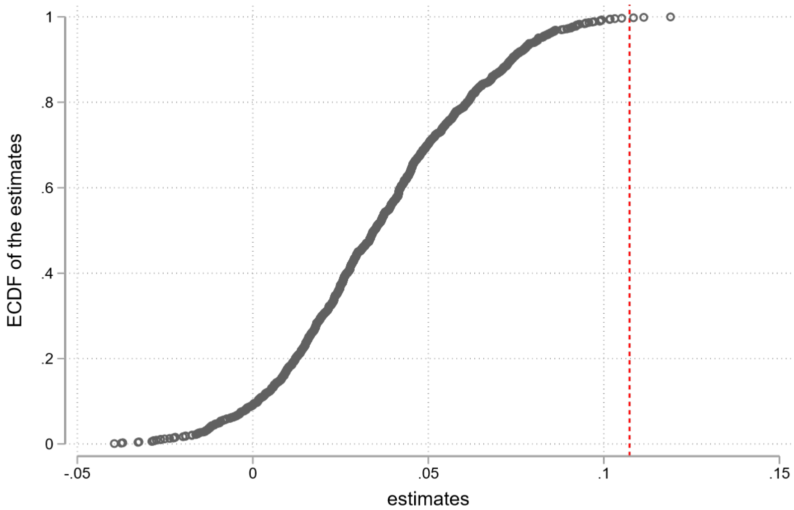
Notes: The figure presents the event study coefficients based on Equation 2 with GSM mobile coverage as only control. The outcome is NTL intensity, measured as the logarithmic sum of NTL intensities, on the *Africapolis* builtup area with a 2-kilometer buffer. The event is defined as the year a country receives its first internet connection via an SMC (potentially through a neighboring country). Confidence intervals are drawn at the 95 percent level using standard errors clustered at the level of the closest access point. The point estimates and standard errors underlying the results are shown in Column (2) of Table 1.

Figure E.6: Dynamic effects of early internet availability on local economic development III



Notes: The figure presents the event study coefficients based on Equation 2 with GSM mobile coverage and the basic geographic controls. The outcome is NTL intensity, measured as the logarithmic sum of NTL intensities, on the *Africapolis* built-up area with a 2-kilometer buffer. The event is defined as the year a country receives its first internet connection via an SMC (potentially through a neighboring country). Confidence intervals are drawn at the 95 percent level using standard errors clustered at the level of the closest access point. The point estimates and standard errors underlying the results are shown in Column (3) of Table 1.

Figure E.7: Distribution of connection placebo estimates



Notes: The figure depicts the empirical cumulative distribution function of the main effect's estimates for 999 permutations of our baseline specification Table 1 (Column 3) with randomly assigned connection years. The vertical line represents the true estimate.

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	Mocâmedes	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%20Performance%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%20Performance%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
Country	City/town	Connection	URL Source
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	Koupela	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Koudongou	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
Camertoon	Yaonde	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	Doula	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
Cameroon	Kribi	2005	https://www.researchictafrica.net/countries/cameroon/Sector_Strategy_for_Telecommunications_and_ICT_2005-2015.pdf

Table F.15: Source register backbone deployment, pre-2009

Country	City/town	Connection	URL source
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
Gambia	Banjul	2005	https://www.siemens.be/cmc/newsletters/index.aspx?id=13-574-16687

Country	City/town	Connection	URL source
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
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/

Country	City/town	Connection	URL source
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
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

Country	City/town	Connection	URL source
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
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
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

Country	City/town	Connection	URL source
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
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
Eswatini	Mbabane	2008	https://www.budde.com.au/Research/Eswatini-Swaziland-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses
Eswatini	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

Country	City/town	Connection	URL source
Eswatini	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
Eswatini	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
Eswatini	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=Azya4sPwq&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=Azya4sPwq&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=Azya4sPwq&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=Azya4sPwq&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=Azya4sPwq&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/
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=0CAIQjRxqFwoTCNCu1MC5noCFQAAAAAdAAAAABAY

Country	City/town	Connection	URL source
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=0CAIQjRxqFwoTCNCu1MC5noCFQAAAAAdAAAAABAY
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.

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