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 Sub-Saharan 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 determined local internet access within countries. Using a sample of incidentally connected mid-sized towns, we estimate that early internet availability increases nighttime light intensity by 10.4%, corresponding to 3.10 percentage points higher GDP growth. Our analysis suggests increased employment is a main driver of this result. Our findings suggest that basic internet connectivity contributes to 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

Sub-Saharan Africa (SSA) has experienced substantial investments in its internet infrastructure by governments, public-private partnerships, and private consortia.[1] At the same time, providing internet access remains complex and costly due to the absence of legacy infrastructure, such as fixed-line telephony networks, and low population density outside major cities (Williams, 2010).[2] Although internet adoption remains low in SSA, due to hardware scarcity, financial constraints, and a low willingness to pay (World Bank, 2016), the limited availability of alternative ICT infrastructure might make internet access particularly critical for the region's development (ITU, 2019). This ambiguity underscores the importance of empirically evaluating whether, and to what extent, basic internet availability fosters development in low-income settings.

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, namely, initial widespread internet availability, in a developing country setting. To this end, we study the first towns that gain internet access.[3] 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 10.4% increase in nighttime light (NTL) intensity in the five years after countrywide internet connection in comparison to towns gaining internet access later. Our findings point to an employment increase of 10.9 percentage points (pp), based on georeferenced Demographic and Health Surveys (DHS). These gains are concentrated in (in-)formal employment for individuals with(-out) higher education.

Our baseline sample includes 184 towns in ten SSA countries that were connected to the global internet infrastructure between 2000 and 2007, and where a national backbone was established prior to this connection outside of larger cities. We tap two main data sources. First, we measure 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 (2024) 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

[1] Investments in SSA's terrestrial national internet backbone exceeded 28 billion USD by 2020 (Hamilton Research, 2024). 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).

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

[3] Guriev et al. (2021) and Adema et al. (2022) investigate mobile internet and analyze a larger sample that includes developed countries.

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.[4] As an implicit first stage, we validate the relationship between internet availability and actual usage using geolocated survey data from the fourth round of the *Afrobarometer*. A cross-sectional regression shows that proximity to an access point is associated with a 3 to 4 pp (36 to 68%, evaluated at the control group's mean) higher individual internet usage.

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.[5] 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. Therefore, we assign the treatment status to towns with access to the national backbone at the time of the countrywide internet connection. The control group comprises (similarly-sized) towns that received their access point only later and thus serve as never-treated units during the estimation period. As internet access at the time occurred predominantly via cybercafés (Southwood, 2022) and we do not observe internet usage, our estimates capture 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. Second, we control for the rollout of mobile coverage as alternative digital infrastructure.[6] Third, we account for changes in physical infrastructure by controlling for market access, which captures improvements in transportation connectivity over time (Donaldson and Hornbeck, 2016; Jedwab and Storeygard, 2022). Fourth, our empirical model further takes into account potential changes in the importance of geographic fundamentals over time. Specifically, 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, ensuring

[4] Internet connections were already possible before. However, they had a limited user base, as they were either satellite-based (e.g., VSAT) or telephony-based (Williams, 2010; Nyezi, 2012), both of which are prohibitively expensive and only allow narrow bandwidths (128 and 56Kbps, respectively). In contrast, first-wave SMCs allowed for speeds between 0.5 and 2Mbps.

[5] 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.

[6] 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.

that observed increases are not simply due to 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 pre-treatment 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 10.4% increase in NTL intensity of towns in the five years after countrywide internet connection, compared to a control group of towns not yet connected via an access point at that time. Applying the established NTL-to-GDP elasticity from Henderson et al. (2012), this implies a 3.10 pp higher economic growth. We decompose this overall effect into measures for intensive- and extensive-margin growth and analyze changes in population density using high-resolution *Gridded Population of the World* data.[7] Rather than a spatial reallocation of economic activity, the findings point to an increase in per-capita output. These positive NTL effects at the town level contribute to the literature on internet availability and development by demonstrating aggregate impacts, complementing evidence of individual-level employment gains (e.g., Hjort and Poulsen, 2019), which do not necessarily translate into measurable effects at higher spatial levels (Buera et al., 2023). Compared to the global 3G coverage effects in Mensah (2021), our estimates are smaller, which is not surprising given that his sample includes many high-income countries. For developing countries, he finds no statistically significant effect.

Second, we use georeferenced DHS data to estimate individual-level employment effects. We find an overall employment increase of 10.9 pp in towns connected earlier, with slightly higher estimates for women. However, disaggregating employment and analyzing heterogeneities by gender and educational level reveals more nuanced patterns. The observed sectoral shifts do not indicate strong structural transformation, as most employment increases are concentrated in agriculture among individuals without higher education, while increases in employment in services are confined to those with higher education. For men, we observe a reallocation from manufacturing toward agriculture and services, accompanied by increases in paid employment. In contrast, women's increases are concentrated in agricultural, unpaid and low-skilled employment. Nevertheless, towns with a higher share of tradable industry, i.e., manufacturing and high-skilled services, exhibit employment growth consistent with structural transformation, particularly through increases in services, aligning with the "production city" framework proposed by Gollin et al. (2016). For a later time period, Hjort and Poulsen (2019) report similar estimates for overall employment, while Caldarola et al. (2023) and Chiplunkar and Goldberg (2022) observe even larger effects for mobile internet. While most studies emphasize larger increases in high-skilled employment, many also report increases in unskilled and agricultural employment, particularly among individuals with a lower educational level.

[7] Extensive-margin growth is defined as changes in the number of lit pixels, while intensive-margin growth refers to changes in the average light intensity of pixels that were already lit in the year before the internet connection was established.

Third, we examine changes in the local population composition, drawing again on DHS data. We find that internet availability increases out-migration, potentially to larger centers, particularly among those born in treated towns, with stronger effects for high-skilled residents. At the same time, treated towns become more attractive only to high-skilled in-migrants. These patterns align with Adema et al. (2022), who find that mobile internet raises migration intentions, and Jiao and Tian (2024), who show that improved internet access facilitates internal migration to larger economic centers.

As mechanisms, we find suggestive evidence that the effects of internet availability work through shared internet access, such as cybercafés, using historical data from *OpenStreetMap* (OSM). We find that cybercafés increase employment, particularly in agriculture among individuals without higher education and among women. While most other amenities and shop types do not show similar effects, we find positive employment effects for restaurants. This aligns with the role of "third places", informal social venues that facilitate interpersonal interaction and network formation, as emphasized by Choi et al. (2024). A second mechanism is financial inclusion. Motivated by the large literature emphasizing the role of financial development in fostering economic growth (e.g., Levine, 1997), we use Zambia's *FinScope* surveys to show that internet availability increases the use of formal financial services, such as current, savings, and fixed deposit accounts, consistent with D'Andrea and Limodio (2024). This increase in formal financial inclusion might indicate an increase in paid employment and contribute to service sector growth.

Apart from absent pre-trends, placebo tests corroborate that the effect on local economic development stems from the specific structure of the exogenous variation we exploit. This makes it unlikely that the estimated effect is confounded by parallel infrastructure rollouts. To further address this concern, we use DHS household responses on electricity access and find no evidence 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 (2021) survey the evolving literature on the economic impact of internet connectivity.[8] 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

[8]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 that infrastructure is beneficial for regional development.

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., 2023).[9] Closely related to our study are Hjort and Poulsen (2019) and Mensah (2021). Mensah estimates increases in NTL intensity induced by 2G and 3G coverage globally, but finds no statistically significant effects of 3G coverage in developing countries. Hjort and Poulsen study the employment effects of large increases in available international bandwidth around 2010 in SSA and find a skill-biased and net positive employment effect at the individual level. While they define the treatment group as being located within 500 meters of the national backbone, and thus compare within cities, we compare across towns and compare towns that receive internet access earlier versus later.

Our study is the first to investigate development, employment, and migration effects of internet availability at basic speeds when the internet became available in SSA. This complements the literature's focus on mobile internet after 2010, a shift that has largely led to the overlooking of cybercafés, which played a central role in early internet access. While mobile internet dominates today, examining this earlier stage of the digital transition remains valuable. Many underserved regions still experience "early-internet-like" conditions. Our findings suggest that even internet at basic speeds can generate substantial development. In particular, the community-based access mode, through cybercafés, might have facilitated community-level digital learning and peer effects, offering a distinct mechanism compared to the more individualized mobile usage (cf. Choi et al., 2024). With a few notable exceptions, such as Jensen (2007), Björkegren (2019), and Manacorda and Tesei (2020), who examine the effects of basic mobile coverage and phones, the literature has largely overlooked the formative phase when ICT first became available in the developing world.[10]

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 providing evidence that connectivity is associated with economic development in smaller, remote towns in developing countries, offering new insights on the digital divide. Although we cannot compare relative development between these towns and larger agglomerations, our findings suggest that unconnected towns fall further behind compared to their incidentally connected

[9] 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.

[10] Jack and Suri (2014) investigate mobile money, which only requires mobile coverage and simple handsets.

counterparts. As such, our results indicate positive effects of ICT infrastructure beyond political and economic centers, pointing to a broader impact of early connectivity.

The remainder of this paper is organized as follows. Section 2 introduces the data, and Section 3 examines the relation between internet availability and internet usage. In Section 4, we outline our empirical strategy. Section 5 presents the main results, Section 6 discusses potential mechanisms, and Section 7 provides robustness checks. Section 8 concludes.

2. Data

We combine data on economic development and internet infrastructure at the level of towns in SSA.[11] 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. 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 geolocation on the African continent. An access point is a node in the national fiber-optic backbone. The data covers the years 2009 through 2020, with updates provided on an annual basis. As such, this information is not sufficient to analyze internet availability in the early and mid-2000s.

Therefore, we infer the construction year preceding the first data observation through an extensive review of national backbone deployment projects across SSA, reaching back to the late 1990s for some countries.[12] Although it is not always possible to determine the exact construction year, the available information allows us to determine 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.[13] 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

[11] 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.

[12] Documentation of our review of deployment projects, including a source register, is provided in Appendix Table F.1.

[13] 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, 1,867 cities and towns are within reach of an access point in 2020, the most recent year of our data.

a country example as well as further background information on national backbone rollouts in SSA.

Internet users in the vicinity of an access point are reached through 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 locations with internet availability tend to also have a cybercafé (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 additional background on last-mile transmission technologies and cybercafés in SSA in Appendix B.2.

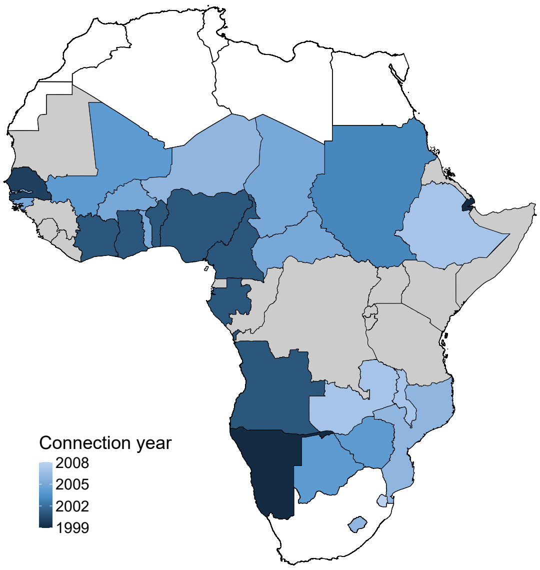
Our second data source is the *Submarine Cable Map* by TeleGeography (2024), a comprehensive collection of information on global submarine cables (SMCs). SMCs are fiber-optic cables for large-scale international data transmission and form the backbone of the international internet infrastructure. SMC construction typically is a joint effort of governments, private investors, and multinational organizations (Williams, 2010). As a result, no individual country can unilaterally determine the year of its SMC connection. From 1999 onward, the first wave of internet-enabled SMCs brought internet connection at a noticeable scale to SSA. SAT-3, for example, the largest first-wave SMC, started operating in 2001 and featured landing points in nine West African countries.[14]

For our empirical analysis, we use the date on which the first-wave SMC started 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 countrywide in all locations with access to the national backbone. International connectivity plays a key role since, especially at the time under study, the vast majority of web pages and applications used in SSA were hosted on servers located in North America or Europe, and thus almost all African internet traffic was routed intercontinentally (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

[14] 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. It has a length of 14,341 kilometers, is owned by a consortium of 36 companies, and costed 650 million USD. 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.

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.

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 first connected to the internet via second-wave SMCs, while white denotes other African countries.

Before the construction of SMCs, internet availability in SSA was extremely 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). Telephony cables are unavailable in the vast majority of SSA and mostly confined to the largest cities. 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 more 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).[15] Usage increased drastically, starting from as low as 0.2 million users in 1998 to reaching 3.2 million by 2002 (Southwood, 2022).

[15]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 an established 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, which allows measurement on the same pixel size after 2013.[16]

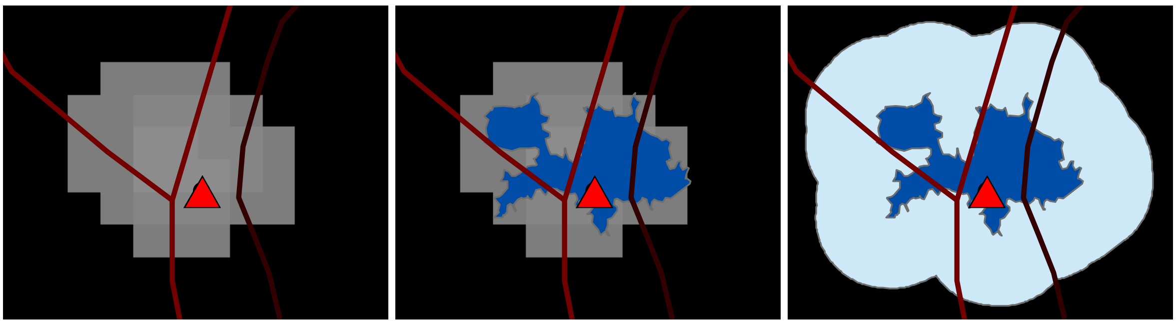
NTL data is an established proxy for local economic development (e.g., Bluhm and McCord, 2022; Asher et al., 2021), especially where official statistics are lacking or unreliable (Nordhaus and Chen, 2015; Henderson et al., 2012; Chen and Nordhaus, 2011). NTL emission by human settlements represents mostly 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, numerous studies validate that this also holds at the sub-national, grid, or city level (e.g., Bluhm et al., 2024; Baum-Snow et al., 2020; Henderson et al., 2018; Campante and Yanagizawa-Drott, 2018; Storeygard, 2016; Chen and Nordhaus, 2011). However, NTLs might not be a good proxy for changes in asset wealth (Yeh et al., 2020). Still, 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 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.

[16] *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 as well as top-coding adjusted NTL data (Bluhm and Krause, 2022) for robustness in Appendix Table C.13.

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.[17]

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, with lighter shades indicating stronger NTL emissions. The spatial concentration of these emissions can clearly be attributed to the town itself. Roads passing 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).[18]

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



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

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 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

[17] *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% of towns feature less than 93,000 inhabitants. In 2000, agglomerations were considerably smaller, with a median population of 11,000, and about 90% of agglomerations were inhabited by less than 47,000 people.

[18] For robustness, we also show the results for a specification without a buffer and with a buffer with a 5-kilometer radius (Appendix Table D.5).

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.[19]

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, which proxies for per-capita output or population density. As this measure is sensitive to newly lit pixels with a low value, we calculate the average NTL intensity on a fixed set of pixels and choose pixels that were lit in the year before the internet connection was established. Second, we calculate the sum of all lit pixels in a town's area to capture 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 development.[20]

2.3. Data processing

We next describe the sample selection procedure and the restrictions that lead to our final set of countries. Our sample consists of 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 mid-2000s, excluding countries first connected after 2008 via second-wave SMCs allowing for substantially higher speeds. This requirement leaves 27 countries, which are listed in Appendix Table D.3. Furthermore, not all countries connected by 2008 had established a national backbone prior to the arrival of the respective SMC or the connection through a neighboring country. In this case, the treatment group is missing as there are no towns with national backbone access right after the connection was established. This requirement further reduces the number of countries in our analysis to 15.[21] Moreover, in Gambia, the treatment group is unavailable as the initial rollout was limited to nodal cities, defined as national and regional capital cities as well as economic centers. We define economic centers as cities with more than 50,000 inhabitants in 2000 according to *Africapolis*.[22] Burkina Faso, Mali, Namibia, and Togo are dropped because no towns qualify as controls (i.e., non-nodal, connected later but not in the post-treatment

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

[20] 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*.

[21] The twelve countries in which not more than the landing point was constructed are: Central African Republic, Ivory Coast, Cameroon, Djibouti, Gabon, Ghana, Guinea-Bissau, Lesotho, Niger, Nigeria, Eswatini, and Chad. In Central African Republic, Guinea-Bissau, Lesotho, and Eswatini, moreover, also no control group exists.

[22] 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. Although 2010 is closer to the connection year for some countries, it is after the connection year for all, making 2000 the appropriate baseline. Robustness checks regarding the population threshold choice are presented in Appendix Tables C.8 and C.9.

period, and fulfilling the NTL emission criterion).[23] Together, these requirements leave a final sample that covers ten countries for our analysis. This process is also depicted in a flowchart in Appendix Figure E.2. Moreover, we show as an external validity check specifications including more countries (Appendix C).

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%) are still unconnected, i.e., without an access point, in 2020. During the post-treatment period (until $t = 5$), 137 towns (25.0%) 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%) are classified as nodal cities. Thus, our main sample contains 184 towns (33.5%) with 89 treatment and 95 control group towns, which corresponds to 12.3% of all *Africapolis* agglomerations in the ten studied countries. For robustness, the 137 towns receiving their access point later are included in a staggered treatment design (Table 8) and nodal cities are step-wise removed in (Appendix Table C.12). The final sample is depicted in Appendix Figure E.3.

3. Internet usage as implicit first stage

Investigating internet availability, measured by proximity to an access point, can only provide an intention-to-treat effect as it does not incorporate actual usage. For the time period we study, data on local or regional internet usage is, however, unavailable. Therefore, we use individual-level, geolocated survey data instead. The *Afrobarometer* included questions on internet usage for the first time in its fourth round (2008 and 2009), i.e., at the end of our observation period and after countrywide internet connections were established (Appendix Table D.3). Still, these questions capture usage at basic speeds for all countries, precede the widespread smartphone adoption, and provide information on usage relatively shortly after the treatment date.[24]

As such, this data allows us to analyze the cross-sectional correlation of internet availability and usage while controlling for geographic fundamentals and demographic characteristics within states. We estimate the following equation using OLS:

$$\text{Usage}_{is(i)} = \gamma_0 + \gamma_1 \text{Access}_i + \mathbf{X}_i' \gamma_2 + \rho_{s(i)} + \epsilon_{is(i)}, \tag{1}$$

[23] In Burkina Faso, all later constructed access points serve exclusively nodal cities. Mali and Namibia connected many towns right after their respective countrywide connection but not at a later point in time. Togo already reached most towns when the internet became available and connected only nodal cities later on.

[24] The DHS has a similar question. However, only five countries (two from the estimation sample) have this question and geolocations for the time when internet was available at basic speeds. Unfortunately, there was also no single survey on internet usage with geolocations before the countrywide internet connections. Results are shown later in Appendix Table D.28.

where $\text{Usage}_{is(i)}$ is an indicator for internet usage, constructed from *Afrobarometer* question Q88C ("How often do you use: The Internet?"), and equals one if the response is more frequent than "never". We are interested in γ_1, which captures the average difference for an individual i in state $s(i)$ who has internet access (Access_i), defined as living within 10 kilometers of an access point, compared to an individual without internet access. Following Ngari and Petrack (2019) and interviews with industry experts, this is an appropriate choice for the distance threshold. The control variables in $\mathbf{X}_i$ account for observable differences in internet use that might be correlated with both proximity to access points and internet usage.[25] We also include state fixed effects $\rho_{s(i)}$ to absorb regional characteristics that may influence both the rollout of infrastructure and individual-level internet usage. We cluster standard errors at the level of the closest access point to account for serial correlation in the error term $\epsilon_{is(i)}$.

Results are shown in Table 1. We provide results for the largest possible sample (Columns 1 through 3), which includes the 27 countries with a basic internet connection from Appendix Table D.3, and for a restricted sample (Columns 4 through 6), including only countries in our main analysis (Section 2.3) with available *Afrobarometer* data. Without excluding nodal cities, internet usage is 3.4 pp higher within the 10 kilometer distance threshold (Column 1). This corresponds to a 36% increase relative to the control group mean, suggesting a sizable effect. Restricting to non-nodal cities slightly reduces the estimate to 3.1 pp (Column 2). In Column (3), we investigate different distance thresholds. We observe the largest point estimate for within 10 kilometers to an access point with 3.4 pp. Between 10 and 25 kilometers and 25 and 50 kilometers, the point estimates are very close to zero and lack statistical significance. Estimates for the restricted sample of countries that are used in the main analysis are similar (Columns 4 through 6). Thus, these findings provide evidence that proximity to the national backbone is associated with increased internet uptake at basic speeds. Robustness checks confirm that the results hold under alternative fixed effects and model specifications (Appendix Table D.4).[26]

[25]The control variables included in $\mathbf{X}_i$ are individual-level demographic characteristics (age, age squared, gender, and educational levels by four categories) as well as basic geographic controls (the log distance to the capital city and indicators for local availability of and log distance to the next road and railroad).

[26]We show robustness checks for Columns (2) and (5) of Table 1, which are repeated in Columns (1) and (5) of Appendix Table D.4. Next, we re-estimate these specifications showing results without control variables in Columns (2) and (6). In all specifications, we use state fixed effects. We then test the robustness for fixed effects at the next lower administrative level (Columns 3 and 4 and 7 and 8).

Table 1: Internet availability and internet usage

Internet usage	(1)	(2)	(3)	(4)	(5)	(6)
Internet availability	0.0342***	0.0307***		0.0388***	0.0378***	
	(0.0123)	(0.0106)		(0.0128)	(0.0126)	
Access point ∈ (0km, 10km]			0.0342***			0.0369**
			(0.0115)			(0.0148)
Access point ∈ (10km, 25km]			0.00523			0.000418
			(0.00576)			(0.00965)
Access point ∈ (25km, 50km]			0.00367			-0.00374
			(0.00476)			(0.00722)
Observations	16,427	12,048	12,048	8,205	5,866	5,866
#Countries	13	13	13	7	7	7
#Enumeration areas	705	577	577	282	243	243
Share treated	0.265	0.107	0.107	0.311	0.131	0.131
R^2	0.355	0.305	0.305	0.317	0.228	0.228
Nodal cities excluded		×	×		×	×
Sample countries				×	×	×

Notes: The table presents estimates based on Equation 1. Internet usage (0/1) from the fourth round of *Afrobarometer*. All regressions include individual-level controls (age, age squared, gender, and educational levels by four categories), basic geographic controls (the log distance to the capital city and indicators for local availability of and log distance to the next road and railroad), and state fixed effects. Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

4. Empirical strategy

4.1. Model specification

Internet availability is not randomly assigned to locations. 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. For each country, there is only one treatment year (i.e., the countrywide internet connection year). We leverage within-country variation by including country-year fixed effects, which implicitly stacks individual country-level estimations. Note that the treatment status is time-invariant as towns are in the treatment group if they get access to the national backbone before or during the countrywide connection year. Thus, there are no "forbidden" comparisons with towns getting later access to the national backbone (Goodman-Bacon, 2021).

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

$$\begin{aligned} Y_{ic(i)t} = \beta_0 + \beta_1 \left(\text{Connection}_{c(i)t} \times \text{Access}_i \right) + \beta_2 \text{GSM}_{it} + \beta_3 \text{MA}_{it}^{2000} \\ + \left(\mathbf{X}_i' \times \text{Connection}_{c(i)t} \right) \beta_4 + \alpha_i + \alpha_{c(i)t} + \varepsilon_{ic(i)t}, \end{aligned} \tag{2}$$

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.[27] The coefficient of interest is β_1 and 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. 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}.[28] Altered transportation infrastructure is captured by the market access measure MA_{it}^{2000}.[29] Lastly, we include a set of geographic controls $\mathbf{X}_i$ 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 log distance to the capital city and indicators for local availability of and log distance to the next road and

[27]This is supported by estimations in Section 3 and robustness checks with alternative distance thresholds (Appendix Table C.7).

[28]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.

[29]We follow Jedwab and Storeygard (2022) to measure market access. In the main specification, we include only variation stemming from newly built or improved roads, holding population constant at its 2000 values from *Africapolis*. Details are provided in Appendix A.2, and robustness checks with alternative specifications are shown in Appendix Table D.39.

railroad.[30] We cluster standard errors at the level of the closest access point to account for serial correlation in the error term $\varepsilon_{ic(i)t}$.[31]

We use an inconsequential treatment approach (Redding and Turner, 2015) to avoid a selection bias from economically and politically important cities. Hence, we focus on incidentally connected towns, and exclude nodal cities, i.e., national and regional capital cities as well as economic centers with more than 50,000 inhabitants in 2000 according to *Africapolis*. By design, our estimates capture the causal impact of early internet availability on mid-sized towns that were not explicitly prioritized in national backbone rollout strategies. This focus enhances internal validity but limits external validity: Our findings might not generalize to large urban areas, where internet adoption patterns, labor markets, and economic structures differ substantially. Instead, the results speak to settings where infrastructure arrives as a by-product of network expansion rather than through targeted investment, a situation common in many remote towns in low-income countries.

Our estimation sample contains ten SSA countries that were first connected to the internet 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.[32] We estimate on a balanced panel with eleven years ($\tau \in \{-5, -4, \ldots, 4, 5\}$, τ being the year relative to the treatment year). 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.[33] 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 ($\tau \in \{1, 2, \ldots, 5\}$).[34]

Simultaneous rollout of the electricity grid and the national backbone in treated but not control group towns might be a threat to isolating the effect of early internet availability. We restrict the sample to towns that emit NTLs in each year of observation.[35] Thus, included towns likely have an electricity connection over the whole observation period (Dugoua et al.,

[30] For robustness, we include a specification with a larger set of geographic controls containing the log distance to the landing point and the regional capital city, indicators for local availability of and log distance to river, port, and coastline, and the log terrain ruggedness index (TRI).

[31] We show robustness to alternative assumptions about the variance-covariance matrix in Appendix Table C.5.

[32] 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.37.

[33] For robustness, we consider control group towns located near the national backbone rollout using an instrumental variable (IV) and triple-differences approach (DDD), as shown in Table C.1.

[34] For robustness, we will treat them as treated in a staggered treatment design in Table 8, where we also have a within-country time-varying treatment. These specifications are estimated using both TWFE and the proposed estimator by Sun and Abraham (2021).

[35] 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).

2018), precluding electricity grid expansion as a confounding factor in our analysis.[36] Additionally, this avoids measurement error due to background noise in the data (Chen and Nordhaus, 2011). This restriction ensures that the captured data represents an appropriate proxy for town-level economic development, at the expense of losing smaller towns.

4.2. 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, a shock first exploited by Hjort and Poulsen (2019). 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 similar (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 originate in Europe and feature one landing point in each SSA country they pass. Thus, single countries have little scope to influence their connection year and the order in which SSA countries are connected is geographically determined.[37] 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 al., 2011).[38] As a consequence, some remote towns exogenously benefit from their location on the route

[36]Nevertheless, we perform robustness analyses with respect to this requirement in Appendix Tables C.14 and C.15. 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.

[37]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.

[38]Panel (a) of Appendix Figure E.4 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.

between nodal cities that are connected prior to SMC arrival. Note that the comparison group are other remote towns that typically 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.[39] 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 no local internet access had been established. This 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:

$$\begin{aligned} Y_{ic(i)t} = \sum_{\tau \neq -1} \Big[\mu_{1\tau} \big(\mathbb{1}_{\tau=\tau} \times \text{Access}_i \big) \Big] + \mu_2 \text{GSM}_{it} + \mu_3 \text{MA}_{it}^{2000} \\ + \big(\mathbf{X}_i' \times \text{Connection}_{c(i)t} \big) \mu_4 + \delta_i + \delta_{c(i)t} + e_{ic(i)t}, \end{aligned} \tag{3}$$

where τ 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 $\tau = 0$. We omit $\tau = -1$ as the reference point. The coefficients $\mu_{1\tau}$ 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. As access point rollout typically follows existing (transportation) infrastructure, our preferred specification controls for proximity to the capital city and transportation infrastructure. Appendix Figure E.6 shows results of cross-sectional balance tests with respect to initial internet access. While estimates for the controls are omitted, balance is achieved across covariates, with only a small association observed for distance to the nearest river.

[39] 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.4 focuses on treated and control towns and shows no clear association between population size and connection timing for control towns. Appendix Figure E.5 displays the density distribution for treated and control towns.

5. Results

5.1. Main effects

We use the difference-in-differences model of Equation 2 to estimate the effect of early internet availability on local economic development at the town level. The regression results are presented in Table 2. We estimate on 184 towns in ten SSA countries, with about half (48.4%) of the towns assigned to the treatment group, and eleven years on a balanced sample.[40] 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. Column (1) only contains town and country-year fixed effects. In Column (2), GSM mobile coverage and market access are 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 4.

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 $\epsilon_{\text{GDP, NTL}} = 0.283$.[41] The resulting GDP growth effects are reported in the last row of Table 2 and are economically significant in size. The effect from our preferred specification in Column (3) of a 10.4% increase in NTL intensity corresponds to a 3.10 pp 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 and market access, which are the only time-varying controls we have. Both estimates lack statistical significance, and their inclusion barely affects the main effect. Their magnitudes are smaller than the main effect and have the expected sign. As mobile coverage is the main alternative digital infrastructure in SSA at the time, this suggests that access points and associated last-mile infrastructure (mainly cybercafés) are driving the main effect and not the slightly earlier rollout of mobile coverage.[42] Increasing model flexibility by including geographic 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 suggests 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. The main effect remains sizable and statistically significant at the 1% level. In Column (4), we add fur-

[40] These countries are Angola, Benin, Botswana, Ethiopia, Malawi, Mozambique, Sudan, Senegal, Zambia, and Zimbabwe.

[41] 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).

[42] We discuss the role of mobile coverage in more detail in Appendix Table D.38. We additionally assess robustness to alternative market access measures in Appendix Table D.39.

Table 2: 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***	0.104***	0.0983***	0.0698***	0.0706**
	(0.0447)	(0.0450)	(0.0374)	(0.0366)	(0.0243)	(0.0327)
Mobile coverage (GSM)		0.0582	0.0511	0.0415	0.00328	0.0492
		(0.0433)	(0.0408)	(0.0397)	(0.0273)	(0.0321)
Market access		-0.0580	-0.0298	-0.0283	-0.000163	-0.0201
		(0.117)	(0.0958)	(0.0982)	(0.0559)	(0.0963)
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	3.10	2.92	—	—

Notes: The table presents estimates based on the main specification in Equation 2. NTL intensity in Columns (1) through (4) is measured as the log sum of NTL intensities. The corresponding economic growth effect in percentage points is calculated as $[[\exp(\hat{\beta}_{\text{connection}\times\text{access}}) - 1] * \epsilon_{\text{GDP, NTL}}] * 100$ using the elasticity $\epsilon_{\text{GDP, NTL}} = 0.283$ from Henderson et al. (2012). The intensive margin in Column (5) is measured by the log 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 log 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 log distance to the capital city and indicators for local availability of and log distance to the next road and railroad. Further geographic controls in Column (4) are the log distance to the landing point and the regional capital city, indicators for local availability of and log distance to river, port, and coastline, and the log terrain ruggedness index (TRI). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

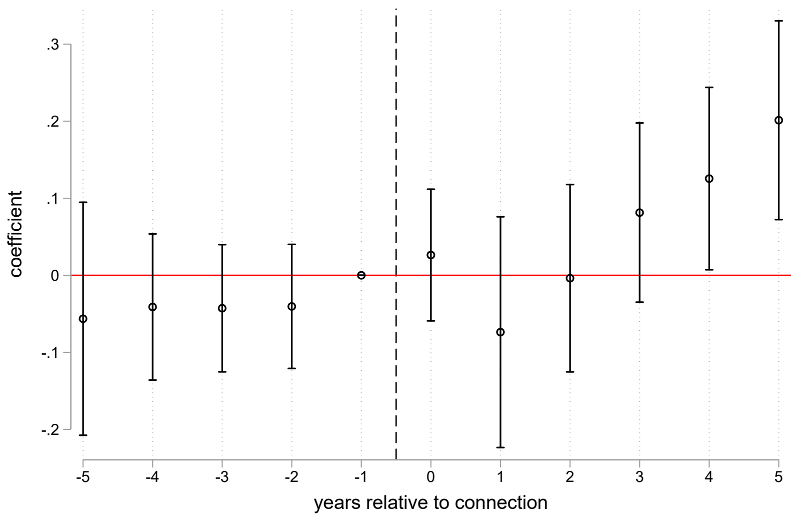
ther geographic controls and the result remains unchanged. This indicates that the main effect is not driven by changes in the economic benefits from geographic fundamentals after the countrywide internet connection was established.

We compare these estimates to Storeygard (2016), where cities in SSA at a similar time are investigated. Our effect in Table 2 (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 one-quarter the size of that reported by Mensah (2021) for 3G mobile internet coverage. However, his results are based on a global sample that includes developed countries, and he finds no significant NTL increases of 3G coverage in developing countries.

Event study estimates. To assess the plausibility of the parallel trends assumption as well as the dynamics of the effect, in Figure 3, we present estimated event study coefficients $\hat{\mu}_{1\tau}$

from Equation 3. 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.[43] 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 fourth post-treatment year onwards, these dynamic estimates are statistically significant. Intuitively, an economic effect from infrastructure rollout takes time to materialize as adoption and behavioral adjustments take time. Our dynamic results suggest a sustained increase due to internet availability in connected towns.

Figure 3: Dynamic effects of early internet availability on local economic development



Notes: The figure presents the event study coefficients based on Equation 3 with GSM mobile coverage, market access, and the basic geographic controls. The outcome is NTL intensity, measured as the log 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% level using standard errors clustered at the level of the closest access point.

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 2. Results show that both margins play a role, but that the intensive margin is estimated more precisely.

[43]Specifications with different sets of covariates, corresponding to Table 2, are shown in Appendix Figures E.7, E.8, and E.9. 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.

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 therefore suggests not a spatial redistribution of activity, but an increase in per-capita output.

We confirm the growth in the intensive margin and effects apart from the surrounding areas (Columns 1 through 3) by only considering the town's center, examining the original *Africapolis* built-up areas in Appendix Table D.5. 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 2 using a 5-kilometer buffer. A stronger effect for the extensive margin cannot be confirmed. However, a lower and less precisely estimated composite effect, likely due to classical measurement error, confirms 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, which are available every five years from 2000 to 2015, and use the log values as the outcome variable in our baseline specification. Appendix Table D.6 reports results for (log-)linear imputed values for missing years (Column 1) and one pre-treatment and one post-treatment data point (Column 2). We find positive but small point estimates, lacking statistical significance. We interpret the results as pointing to an increase in per-capita output, i.e., higher output with (roughly) the same population, rather than a spatial redistribution of economic activity.

5.2. Individual-level evidence

To complement the town-level findings, we next examine individual-level employment outcomes using georeferenced DHS. This analysis helps unpack the mechanisms behind the observed aggregate development effects and offer a more granular perspective on who benefits from early internet availability. In addition to employment, we later investigate migration, bank accounts, and technological devices as potential drivers of town-level development. We use harmonized, repeated cross-sectional data from the *IPUMS DHS* (Boyle et al., 2022), which we link to towns in the *Africapolis* dataset using geocoded survey clusters. We estimate Equation 2, adding age, age squared, gender, marriage status (six categories), and educational levels (four categories) as individual-level controls, on one pre- and one post-treatment survey per country, selected based on proximity to the treatment year.[44]

[44] 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). Angola had no survey prior to its internet connection in 2001. Botswana and Sudan had only one very early survey and, in particular, no survey after their respective internet connection. For Mozambique and Zambia, there are no geocodes for their respective pre-treatment survey.

Employment. We begin by reporting the main results for overall employment in Table 3. While Columns (1) through (3) report specifications that include only fixed effects, Columns (4) through (6) add controls. Across specifications, we find a statistically significant increase in employment of 10.3 to 10.9 pp (Columns 1 and 4). Column (2) shows that this increase is driven entirely by female employment.[45] Although the point estimates are positive for individuals with higher education, they are not statistically significant (Columns 3 and 6). Only the gender-specific effect becomes more balanced, once controls are added (Column 5). Moreover, the inclusion of controls improves the precision of the estimates throughout.[46]

Table 3: The effect of early internet availability on employment

Employment	(1)	(2)	(3)	(4)	(5)	(6)
Connection × Access	0.103***	-0.000994	0.0819*	0.109***	0.0377	0.0888**
	(0.0363)	(0.0730)	(0.0423)	(0.0298)	(0.0644)	(0.0385)
Connection × Access × Female		0.131*			0.0837	
		(0.0741)			(0.0597)	
Connection × Access × Education (high)			0.0464			0.0475
			(0.0859)			(0.0842)
Observations	4,422	4,422	4,422	4,422	4,422	4,422
#Countries	5	5	5	5	5	5
#Towns	35	35	35	35	35	35
Share treated	0.394	0.394	0.394	0.394	0.394	0.394
R^2	0.136	0.164	0.152	0.285	0.288	0.286
Town FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×
GSM coverage				×	×	×
Market access				×	×	×
Geographic controls				×	×	×
Individual controls				×	×	×

Notes: Employment from DHS (0/1). Controls as in Column (3) of Table 2 plus individual-level controls: age, age squared, gender, marriage status (six categories), and educational level (four categories). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

To better understand the nature of the employment increases, we next examine sectoral changes in Table 4.[47] The largest increases occur in agriculture (Column 1), with no substantial gender differences (Column 2) but concentrated entirely among individuals without higher education (Column 3). In contrast, manufacturing shows a small and statistically in-

[45] We implement heterogeneities using a three-way interaction term, where all lower-order interaction terms required are included in the specification or absorbed by the fixed effects. We examine educational heterogeneity, defining high education as beginning with secondary schooling.

[46] We assess the robustness of Columns (4) through (6) of Table 3 by relaxing restrictions and thus increasing the sample. First, we use region fixed effects at the second administrative level (admin-2), as shown in Appendix Table D.7 (Columns 1 through 3). Second, we lift the NTL restriction in Columns 4 through 6 of the same table. The former shows similar results but a smaller increase in female employment relative to male employment. The latter shows smaller overall employment effects, but with consistent coefficient signs.

[47] Appendix Table D.8 shows the sectors' definitions and frequencies derived from DHS occupations ("current job"). These broad categories are necessary as countries have different sub-categories (Appendix Table D.9).

significant decline (Column 4), driven primarily by men (Column 5), with no clear differences by educational level (Column 6). For services, we observe a small and statistically insignificant increase (Column 7), but a lot stronger increases for individuals with higher education (Column 9) and, though not statistically significant, a larger increase for men (Column 8).[48] These results suggest that additional jobs are created in agriculture and, for individuals with higher education, in services, rather than reflecting structural transformation in the sense of a shift from agriculture to manufacturing and services. These results align with evidence that even basic internet access helps farmers obtain market-price information (George et al., 2011), manage deliveries and supplies, and advertise their products (Mbarika et al., 2004; Gitta and Ikoja-Odongo, 2003).

Table 4: Early internet availability and employment by sector

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Agriculture			Manufacturing			Services		
Connection × Access	0.122**	0.107	0.146***	-0.0370	-0.132**	-0.0407	0.0244	0.0628	-0.0163
	(0.0462)	(0.0919)	(0.0464)	(0.0251)	(0.0651)	(0.0278)	(0.0543)	(0.0896)	(0.0678)
Connection × Access × Female		0.0126			0.119*			-0.0476	
		(0.0901)			(0.0701)			(0.0809)	
Connection × Access × Education (high)			-0.129**			0.0225			0.154*
			(0.0483)			(0.0467)			(0.0885)
Observations	4,422	4,422	4,422	4,422	4,422	4,422	4,422	4,422	4,422
R^2	0.243	0.244	0.248	0.137	0.141	0.137	0.156	0.156	0.158
Town FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×

Notes: Occupation from DHS (0/1). Sample and controls as in Table 3 (Columns 4 through 6). 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 next investigate changes in the skill level of employment, following the approach of Hjort and Poulsen (2019).[49] Appendix Table D.12 shows basically no changes in high- and mid-skilled employment but a statistically significant increase of 10.3 pp in low-skilled employment (Columns 1, 4, and 7), likely reflecting the increase in agricultural employment. For individuals with higher education, we find positive estimates in high- and mid-skilled employment (Columns 3 and 6) and a negative deviation in low-skilled employment (Column 9), consistent with the sectoral shifts observed earlier. For low-skilled employment, we observe a negative estimate for men but a large and statistically significant increase for women (Column 8), further underscoring the gender-specific employment effects.

[48] Results are similar when we relax restrictions by using region fixed effects (Appendix Table D.10) and by lifting the NTL restriction (Appendix Table D.11).

[49] High-skilled jobs are defined as occupations in "professional, technical, or managerial". Mid-skilled jobs are defined as occupations in agriculture (if not stated that it is self-employment), "manual" (if not stated that it is unskilled), "clerical", "clerical or sales", "sales", and "services". Low-skilled jobs are defined as occupations in "household, domestic, and services", "household and domestic", agricultural self-employment, "unskilled manual", and "other". However, countries do not have homogeneous categories for mid- and low-skilled employment: Senegal does not differentiate between skilled and unskilled manual work, whereas Benin and Ethiopia do not differentiate between employee and self-employed agricultural (Appendix Table D.9).

Our data allows us to investigate employment in greater detail. First, we disaggregate employment in services into sub-categories (Appendix Table D.13).[50] We find no changes in employment in sales (Column 1), although men appear to benefit more than women (Column 2). In contrast, employment in (domestic) services increases (Column 4), particularly for women (Column 5). For both categories, estimates for individuals with higher education lack statistical significance, though the point estimate for sales is positive and sizable (Columns 3 and 6). Second, we examine variation by payment type. We find that unpaid employment increases (Appendix Table D.14, Column 1), particularly among individuals without higher education (Column 3), with no gender differences (Column 2). In contrast, increases in cash-only employment lack statistical significance (Column 4), despite larger point estimates for men (Column 5) and those with higher education (Column 6). Last, we examine variation by employment relationship. Appendix Table D.15 shows that employment increases are split between self-employment (Column 1) and working for someone else (Column 7), while family employment declines slightly (Column 4). The increases are more pronounced for women (Columns 2 and 8). For individuals without higher education, employment increases are concentrated in self-employment (Column 3), whereas for those with higher education, the increase is primarily in jobs working for others (Column 9). These dimensions underline differential effects for individuals without higher education and women compared to individuals with higher education and men.

To further understand the employment effects of internet access, we examine heterogeneity by towns' pre-treatment sectoral composition, following Gollin et al. (2016). As in (Jedwab et al., 2025), we define the tradable sector as manufacturing, high-skilled services, and sales, which are indicative of "production cities". Agriculture and domestic services are grouped into the non-tradable sector, reflecting "consumption cities". We interact the standardized, i.e., mean zero and unitary standard deviation, pre-treatment share of each sector with the treatment indicators. Appendix Table D.16 shows that the overall employment effect is marginally statistically significantly larger in towns with a higher initial tradable share (Column 1). These towns exhibit a statistically significant negative deviation in agricultural employment (Column 2), no differential change in manufacturing (Column 3), and a statistically significantly larger increase in employment in services (Column 4), consistent with complementarities between tradable industry and local services. This suggests that early internet access amplifies existing economic capacity, consistent with the "production cities" logic of Gollin et al. (2016). In contrast, towns with a higher initial non-tradable share show statistically significantly negative deviation in overall employment effects and a pronounced negative deviation in employment in services (Appendix Table D.17). While their employment still increases, the gains are

[50] The broad services sector can be split into consistent categories: "professional, technical, or managerial" (the only category in high-skill employment), "sales" (composed mainly of sales and partly includes clerical as well), and "services (domestic)" (composed of three categories: "household and domestic", "household, domestic, and services", and "services"). Agriculture and manufacturing do not allow for such a decomposition.

concentrated in agriculture and manufacturing and do not extend to services, suggesting that connectivity alone might not spur structural transformation in "consumption cities".

To summarize, although there is an increase in overall employment, and a slightly higher one for women, disaggregated results reveal distinct gender- and education-specific patterns. For women, the employment increase is predominantly in agriculture, and characterized as low-skilled and unpaid. In contrast, men switch from manufacturing to agriculture and services, with an increase in paid employment. A similarly divergent pattern emerges by educational level. Individuals with higher education find employment in services, are paid, and work for someone else, whereas those without higher education find employment in agriculture, low-skilled, unpaid, and in self-employment.[51] Beyond individual-level patterns, we also observe differences by towns' sectoral profile. Towns with a larger initial share of tradable sectors, such as manufacturing and high-skilled services, experience larger employment increases, particularly in services.

The effect size we document falls within the range reported by Hjort and Poulsen (2019) and exceeds their estimates based on DHS data. Consistent with their findings, we observe increases in more formal employment (paid and for someone else) and in services, for individuals with higher education. However, unlike their results, we also find substantial increases in agricultural and low-skilled employment, particularly among women and individuals without higher education, likely contributing to our larger overall effects. Studies on mobile internet rollout report even stronger effects (Caldarola et al., 2023; Chiplunkar and Goldberg, 2022). In line with our findings, Chiplunkar and Goldberg (2022) report increases in informal employment among women and formal employment among men. In contrast, Caldarola et al. (2023) report employment increases across all skill levels and sectors, with larger effects in high-skilled employment and services.

Migration. The DHS records how long individuals have lived at their current location. We use this information to analyze how early internet availability affects internal migration patterns. Specifically, we construct three mutually exclusive outcomes: (i) recent in-migrants, i.e., individuals who moved to the town after the internet became available, (ii) long-term in-migrants, i.e., those who moved before the internet became available, and (iii) non-movers, i.e., those born in the town.[52] One important limitation is that the DHS surveys only current residents. We therefore cannot observe individuals who left the town after the internet became available. Our results capture compositional changes among those who remain, not net migration flows. This distinction is important, as internet availability might increase out-migration to larger economic centers (Jiao and Tian, 2024).

[51] Although the patterns for women and individuals without higher education are similar, their correlation is weak (coefficient of -0.19).

[52] We construct these outcomes from the pre-treatment surveys using the same number of years between the internet connection and the post-treatment survey. Additionally, this reflects changes in shares, not levels. Since the DHS is not representative at the town level, reporting population counts or changes in levels would be misleading.

Estimation results are presented in Table 5.[53] We find a large decrease for non-movers (Column 7). Since this group contains no in-migrants by definition, their declining share must reflect either (i) relatively higher out-migration compared to the moved-since-longer group, or (ii) growth in the other groups that reduces the non-movers' share. In contrast, we observe a large increase for the moved-since-longer group (Column 4). Because these individuals moved before internet availability, their share can only rise if they experience lower out-migration (relative to non-movers) or if fewer new in-migrants arrive, increasing their relative weight. For recent in-migrants, we find a small decrease (Column 1), consistent with fewer new arrivals or less out-migration among the other groups. Taken together, the absence of an increase among recent in-migrants, combined with the fall in non-movers and rise in long-term in-migrants, suggests that out-migration is disproportionately higher among non-movers. This interpretation is consistent with the idea that long-term in-migrants face higher mobility costs or are less able to benefit from new internet access than non-movers. Additionally, we investigate the moved-recently and moved-since-longer groups in an event study design using post-treatment surveys only, with years since the countrywide internet connection as the time variable. Appendix Figure E.10 shows that since the internet became available, there are fewer in-migrants in treated towns, while prior to the treatment, there is no clear trend. This provides suggestive evidence that fewer people move in. Combined with the decrease for non-movers, this points to an overall negative effect on treated towns' size.

Table 5: The effect of early internet availability on migration

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Moved recently			Moved since longer			Non-mover		
Connection × Access	-0.0547*	0.00476	-0.0973***	0.211***	0.258***	0.225***	-0.164*	-0.119	-0.138*
	(0.0315)	(0.0926)	(0.0261)	(0.0684)	(0.0853)	(0.0657)	(0.0860)	(0.156)	(0.0784)
Connection × Access × Female		-0.0801			-0.0535			-0.0490	
		(0.0937)			(0.0739)			(0.101)	
Connection × Access × Education (high)			0.127*			-0.00654			-0.117
			(0.0693)			(0.0814)			(0.105)
Observations	3,868	3,868	3,868	3,979	3,979	3,979	3,868	3,868	3,868
#Countries	4	4	4	4	4	4	4	4	4
#Towns	30	30	30	30	30	30	30	30	30
Share treated	0.403	0.403	0.403	0.417	0.417	0.417	0.403	0.403	0.403
R^2	0.115	0.117	0.117	0.164	0.166	0.166	0.123	0.125	0.124
Town FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×

Notes: Migration variables from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

These findings align with prior research on migration responses to digital connectivity. Adema et al. (2022) find that mobile internet increases migration aspirations, particularly for higher-income individuals, while Jiao and Tian (2024) show that improved internet access facilitates

[53] Robustness checks indicate similar results (Appendix Tables D.18 and D.19). Also, the sample decreases by one country as the migration question is not available for Ethiopia.

internal migration to larger economic centers by reducing information asymmetries and search costs, leading to increased mobility among skilled workers.

Interestingly, for individuals with higher education, we find a positive estimate for recent in-migrants (Column 3), suggesting that while fewer people moved in overall, those who did were more likely to be highly educated.[54] To explore whether these shifts are reflected in aggregate town-level characteristics, we examine changes in the towns' educational composition. Appendix Table D.20 provides suggestive evidence that the share of individuals with higher education declines in treated towns, consistent with a relative outflow of high-skilled residents, in line with Jiao and Tian (2024).[55]

When separating the education effects by migration group in Appendix Table D.21, we find that the negative point estimates are driven by the moved-since-longer group, with similar negative point estimates for both men and women (Columns 3 and 4). We only find positive, though statistically insignificant, coefficients for recent in-migrants, with a particularly large positive effect for men (Columns 1 and 2), consistent with patterns in Table 5. Non-movers' education remains unchanged (Columns 5 and 6). These results suggest that individuals with higher education who lived in treated towns before the internet became available are more likely to leave, whereas the presence of recent in-migrants with higher education points to treated towns continuing to attract skilled individuals.

Employment by migration. We show next employment effects by migration group. Appendix Table D.22 re-estimates the main employment specifications, i.e., Columns 4 through 6 of Table 3, separately for each migration group.[56] We find no effect for individuals who moved before internet became available (Column 4), but observe positive effects for both recent in-migrants and non-movers (Columns 1 and 7), with the effect being larger for the former. Notably, these two groups differ in terms of educational heterogeneity. Among recent in-migrants, employment effects are a lot larger for individuals with higher education (Column 3), whereas among non-movers, effects are larger for individuals without higher education (Column 9). These results are in line with the previous analysis. Recent in-migrants represent a positively selected group with higher educational attainment, while the moved-since-longer group likely experienced selective out-migration of more capable individuals.

[54] Other heterogeneities lack statistical significance but can me meaningful: For individuals with higher education, the negative effect on non-movers is stronger (Column 9). Moreover, the negative effects for recent in-migrants are driven by women (Column 2); for non-movers, the positive effects are also stronger for women (Column 8); and for individuals who moved there a longer time ago, the positive effects are weaker for women (Column 5).

[55] This pattern holds across all three specifications, although it reaches marginal statistical significance only in the specification with the largest sample size. Ethiopia is excluded to ensure comparability with the migration sample.

[56] For robustness, Appendix Table D.23 shows overall employment effects excluding Ethiopia (which lacks migration data). Effects are comparable, with slightly smaller point estimates and a more precisely estimated effect for women.

For the non-movers, there is no selective out-migration, so we see average effects and increases concentrated among individuals without higher education.[57]

Banking and digital devices. The DHS also allows us to investigate differences in ownership of bank accounts and digital devices (namely, mobile phones and computers) between treated and control towns. However, these questions were not widely included in earlier DHS rounds.[58] Therefore, we estimate cross-sectional OLS regressions with state fixed effects to provide suggestive evidence on possible mechanisms, further explored in Section 6. Results in Appendix Table D.28 show that individuals in treated towns are more likely to own a bank account (Column 1), consistent with findings in D'Andrea and Limodio (2024). We also find a higher rate of mobile phone ownership (Column 2), suggesting complementarities between internet infrastructure and mobile access. The estimate for computer ownership is likewise positive but only marginally statistically significant (Column 3), which is consistent with the limited role of private computers, given that internet access during this period primarily occurred via cybercafés. Finally, the positive estimate for internet usage, shown in Column (4), provides additional support to our implicit first stage results (Section 3). Gender and educational heterogeneities do not reveal substantial differences (Appendix Tables D.29 and D.30). We investigate this further in the next section using data from Zambia's *FinScope* surveys.

6. Further mechanisms

The role of cybercafés. Cybercafés were the predominant mode of internet access prior to the expansion of mobile internet (Appendix B.2).[59] Unlike later mobile-based internet access, the cybercafé era in SSA was characterized by shared access, bringing users together, both online, through chat and email, and offline (Sairosse and Mutula, 2004; Boase et al., 2003). Cybercafés thus function as "third places" (Choi et al., 2024), which might help explain why we observe employment effects, particularly among individuals without higher education. While cybercafés offered limited bandwidth and functionality, e.g., email, online chatting, and, basic web browsing (Sairosse and Mutula, 2004), their shared, community-based access model potentially enhances digital spillovers and peer learning effects (Cilesiz, 2009).

To investigate cybercafés more directly as a potential mechanism, we draw on geospatial data from *OpenStreetMap* (OSM), which includes timestamps indicating when features such as amenities were added (OpenStreetMap, 2025). Since OSM was still relatively new at the time, we can backdate entries only to 2013 to proxy the presence of cybercafés across towns

[57]Sectoral analyses by migration group (Appendix Tables D.24 through D.27) reinforce earlier patterns. Notably, increases in services are concentrated among recent in-migrants and individuals with higher education across all migration groups (Appendix Table D.26).

[58]The bank account question was asked in both rounds only in Ethiopia; the mobile phone question only in Malawi.

[59]In 2006, the DHS in Benin asked respondents about their mode of internet access; 69% of those with internet access reported using cybercafés. However, this survey lacks geocodes, making it impossible to spatially link responses to the location of internet access points.

during our observation period.[60] As only a few non-nodal cities have cybercafés recorded in 2013, we relax our incidental treatment approach and expand the estimation sample to include larger cities and regional capitals.[61]

Estimates in Table 6 show that the presence of at least one cybercafé is associated with an increase in overall employment of about 4 pp (Columns 1 and 4). This effect is primarily driven by female employment (Columns 2 and 5), with no difference by educational levels (Columns 3 and 6).[62] Due to measurement error, these estimates might be downward biased and less precisely estimated, yet they are robust to alternative specifications.[63] Sectoral outcomes based on cybercafé presence, shown in Appendix Table D.33, broadly align with the patterns in the baseline specification using internet access points (Table 3). We find large increases in agricultural employment (Column 1), particularly among individuals without higher education (Column 3). Although we observe a small decrease in employment in services (Column 7), even for individuals with higher education (Column 9), this is consistent with the overall absence of employment increases for this group and underscores the stronger relevance of cybercafés for individuals without higher education.

The role of other local infrastructure. While cybercafés play a key role in facilitating internet access, and their presence shows positive employment effects, we also examine whether other local amenities shape the impact of early internet availability. To do so, we re-estimate Column (4) of Table 6 for a broad set of amenities listed in OSM.[64] For most amenities, the estimates are close to zero and lack statistical significance (Appendix Table D.35). A notable exception is restaurants, which show a large positive effect, unlike regular cafés, fast food outlets, bars, pubs, or nightclubs. This pattern aligns with Choi et al. (2024), who investigate the role of "third places" for entrepreneurship using the opening of *Starbucks Cafés* in the US

[60] We isolate cybercafés by selecting all data stating terms like "cyber", "internet", or "wifi" and cleaning it such that only places with public internet access remain. For instance, internet providers, hotels, hospitals, restaurants, and regular cafés are removed. As the data is from 2013, we cannot know whether (1) the cybercafé was established earlier or more recently, and (2) other places have a cybercafé as well, which is just not marked in OSM. Due to the latter, we disregard places with no cybercafé that had internet access by 2013 in the main specification. This restriction is relaxed in a robustness check (Appendix Table D.32).

[61] National capitals and landing points are still disregarded. Moreover, this relaxation is removed in a robustness check (Appendix Table D.32). The estimation sample contains Ethiopia, Ghana, Malawi, and Senegal.

[62] By construction, there are no locations with a cybercafé that have no internet access point. But about a quarter of cybercafé locations have no internet access point close by, reflecting the imprecision in the 10 kilometers threshold. For robustness, we re-estimate using the same restrictions, and thus the same sample, but with the access point data (Appendix Table D.31). Estimates are very similar.

[63] In Appendix Table D.32, we do not disregard cities with internet access and no cybercafés (Columns 1 through 3), disregard regional capitals and larger cities (Columns 4 through 6), and replace town fixed effects with region fixed effects (Columns 7 through 9). As population threshold, the value of 100,000 inhabitants is applied. With 50,000 inhabitants, the sample would shrink to one country and thirteen towns. The results remain, supporting the interpretation of cybercafés as an enabling mechanism. Only in the stricter nodal city specification, point estimates lack statistical significance at conventional levels as the sample shrinks to two countries and 30 cities.

[64] We include all amenities with at least 250 entries across Africa in 2013 (Appendix Table D.34) and report employment coefficients for those with at least 5% treated observations. As OSM requires internet access, all estimates capture the effect of the amenity conditional on internet availability.

Table 6: Cybercafés and employment

Employment	(1)	(2)	(3)	(4)	(5)	(6)
Connection × Cybercafé	0.0423	-0.0323	0.0375	0.0444*	-0.00276	0.0426
	(0.0257)	(0.0375)	(0.0358)	(0.0240)	(0.0374)	(0.0334)
Connection × Cybercafé × Female		0.0984**			0.0600	
		(0.0433)			(0.0456)	
Connection × Cybercafé × Education (high)			-0.00394			-0.00401
			(0.0541)			(0.0603)
Observations	11,987	11,987	11,987	11,987	11,987	11,987
#Countries	4	4	4	4	4	4
#Towns	63	63	63	63	63	63
Share treated	0.462	0.462	0.462	0.462	0.462	0.462
R^2	0.076	0.116	0.081	0.236	0.237	0.237
Town FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×
GSM coverage				×	×	×
Market access				×	×	×
Geographic controls				×	×	×
Individual controls				×	×	×

Notes: Employment from DHS (0/1). Historic cybercafés from 2013 from OpenStreetMap (2025) as time-invariant treatment dummy. Controls as in Table 3 (Columns 4 through 6). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

in the early 2000s. Beyond cybercafés and restaurants, few other amenities show meaningful effects.[65] We also examine the role of local commercial activity using OSM shop categories (Appendix Table D.36). Again, most shop types show no positive effects, with the exception of stationery shops, which exhibit a relatively large positive effect, potentially reflecting complementary employment for skilled labor. Overall, these results underscore the distinctive role of cybercafés in fostering informal employment.

Financial inclusion. Financial inclusion is widely regarded as a key driver of economic development (e.g., Levine, 1997). Consistent with this view, the DHS evidence already suggested a growing role for banking. To explore this mechanism in greater detail, we draw on Zambia's *FinScope* surveys from 2005 and 2009 (FinMark Trust, 2006, 2010).[66] Table 7 shows posi-

[65] Educational institutions generally have positive coefficients, likely due to their use of computers with internet access. However, only schools show a marginally statistically significant estimate. Public buildings also show a positive effect, unlike town halls or community centers. Marketplaces and post offices show positive impacts, suggesting a role for local trade. Somewhat unexpectedly, we find no impact for financial institutions. There is also no effect from transportation infrastructure, although ferry terminals show a positive impact, potentially reflecting higher effects through international trade. For places of worship, which is the most frequently listed amenity and for which the most cities are included, we estimate a null effect. Likewise, other non-commercial locations, such as theaters, cinemas, or health facilities, show no positive effects.

[66] As with DHS, we use one survey prior to Zambia's internet connection, which was established in 2007 through Zimbabwe (Appendix Table D.2), and one from after. Although limited to a single country, the *FinScope* survey offers detailed insights into financial behavior and access during the period when the early internet became available. The surveys include district identifiers, which we match to towns from *Africapolis*. For larger districts, we assign them to the largest city. Due to the single-country focus, the sample size is small. We retain our main estimation strategy but omit the NTL restriction, yielding 21 towns to estimate on.

tive, though imprecisely estimated, increases in the likelihood of having and using the most common financial products, consistent with findings by D'Andrea and Limodio (2024). In particular, we find increases for current, savings, and fixed deposit accounts. These products typically require interaction with formal financial institutions, such as banks or post offices, unlike informal savings groups or cash holdings. The results thus suggest that internet availability facilitates a shift toward greater formal financial inclusion. This shift might reflect an increase in paid employment and might also support the expansion of employment in services.

Table 7: The effect of early internet availability on financial access

	(1) Bank account	(2) ATM/cashpoint card	(3) Debit/connect card	(4) Current/cheque account	(5) Savings account	(6) Fixed deposit account
Connection × Access	0.0577	0.0631	0.0137	0.0515*	0.0742**	0.0201**
	(0.0472)	(0.0569)	(0.0122)	(0.0257)	(0.0348)	(0.00762)
Observations	2,269	2,267	2,263	2,266	2,268	2,262
#Towns	21	21	21	21	21	21
Share treated	0.409	0.409	0.409	0.409	0.409	0.409
R^2	0.501	0.333	0.067	0.103	0.477	0.046
Town FE	×	×	×	×	×	×
Year FE	×	×	×	×	×	×

Notes: Answering "have and use" of different financial products in Zambia's *FinScope* surveys (0/1). Controls as in Column (3) of Table 2 plus individual-level controls: age, age squared, gender, marriage status (four categories), and educational levels (eleven categories). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

7. Robustness

Model specification. Defining the control group as towns that receive an access point only after the post-treatment observation period ensures a non-contaminated control group and, thus, a clean identification strategy. However, this approach introduces a gap of at least six years between treated and control towns. In Table 8, we address this issue by employing a staggered treatment design. Specifically, we assign the year of access point construction as the treatment year, rather than using the countrywide internet connection established through an SMC. As a result, the treatment year is now defined at the town level rather than the country level.[67] While the control group remains unchanged, towns that receive an access point within five years of the SMC arrival are not excluded but instead enter the treatment group in the year they gain access, expanding it by 81 towns. This adjustment slightly alters the interpretation of the treatment: Rather than capturing only the effect of early internet availability, we now

[67] We first show estimation results using TWFE, followed by results based on the estimator by Sun and Abraham (2021), which accounts for the staggered treatment and provides robustness to potential biases in TWFE specifications.

estimate the broader effect of internet availability at basic speeds on local economic development.

In Columns (2) and (3) of Table 8, we first add mobile coverage and market access and then geographic controls as in the main specification (Columns 2 and 3 of Table 2). The effect is slightly smaller (8.8 to 7.6 pp in comparison to 13 to 10 pp), and also, the decline of the estimate when controlling for mobile coverage and market access, 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 through second-wave SMCs is added to the treatment group.[68] Being about 1 pp higher, the estimated effect remains highly similar.

Table 8: Model specification: Staggered treatment

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)
Internet availability	0.0855***	0.0882***	0.0760***	0.0954***	0.0973***	0.0857***
	(0.0308)	(0.0311)	(0.0276)	(0.0308)	(0.0309)	(0.0280)
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
R^2	0.935	0.935	0.936	0.937	0.937	0.938
Town FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×
Mobile coverage (GSM)		×	×		×	×
Market access		×	×		×	×
Geographic controls			×			×
Post-treatment period	×	×	×			
Before speed upgrade period				×	×	×

Notes: NTL intensity is measured as the log 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 2. Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

[68] Consequently, some towns that were previously in the control group become part of the treatment group if they receive their access point after the five-year post-treatment period but before the speed upgrade. At the same time, 20 towns that receive their access point within the five years after the initial countrywide internet connection but only after the speed upgrade are excluded from the analysis. This adjustment affects countries with a short interval between the initial and second-wave SMC: eight towns each from Malawi and Mozambique, and four from Zambia. Compared to Columns (1) through (3), this adjustment results in a smaller sample but a higher proportion of treated towns.

In contrast to the main specifications, where treatment status remains constant over time and temporal variation is solely induced through interactions with the countrywide connection years, the specifications in Table 8 allow for time-varying treatment status within countries. To address potential "forbidden comparisons" between late- and early-treated towns (e.g., Goodman-Bacon, 2021), we re-estimate the results using the estimator proposed by Sun and Abraham (2021). The corresponding event study for Column (3) of Table 8 is presented in Appendix Figure E.11, and the one for Column (6) in Appendix Figure E.12. For comparison, we also report the respective TWFE event studies in Appendix Figures E.13 and E.14. Across all specifications, the results remain robust.

A related concern might be that towns connected via 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.37, we address this concern by re-estimating our baseline specification, Equation 2, 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.

Beyond timing, a further concern might be that due to their geographical distance, treatment and control group towns might not be comparable. In Appendix Table C.1, we address this by exploiting variation in internet access among geographically proximate towns. We implement an instrumental variable (IV) and a triple-differences (DDD) approach. For the IV approach, we instrument internet access using the distance to the minimum spanning tree (MST) that connects all nodal cities at the time of the countrywide internet connection, following a method similar to Faber (2014). The DDD specification compares towns (1) before and after the countrywide internet connection, (2) with and without an access point at a road that was followed during the initial national backbone rollout, and (3) with and without an access point at a road that was followed at a later point in time of the national backbone rollout. While focusing on nearby towns improves comparability, it might introduce the risk of displacement effects, with economic activity shifting from control to treated towns and potentially violating SUTVA. Notably, both approaches yield larger effect sizes than the baseline. Further details are provided at the beginning of Appendix C.

Further restrictions are shown in Appendix Table C.2. These specifications include restrictions regarding the road network and the most important road, the smallest towns, the years when internet speed was increased due to second-wave SMCs, and ethnic favoritism. At the country level, we perform two additional checks. First, we re-estimate the main specification while sequentially excluding each country (Appendix Table C.3). Second, we restrict the sample to countries with more than one or two towns in either the treatment or control group (Appendix

Table C.4), addressing concerns of limited variation and sensitivity to idiosyncratic shocks. Moreover, we show robustness to alternative assumptions about the variance-covariance matrix in Appendix Table C.5. In Appendix Table C.6, we use different specifications of the distance to the capital city. Besides the log distance, we re-estimate Equation 2 using the linear, quadratic, and cubic distance. All robustness checks are discussed in detail in Appendix C and collectively confirm the stability of our main results across alternative model specifications.

In Table 9, 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 market access and the geographic controls in Columns (2) and (3), respectively. 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 pp larger in comparison to Table 2 (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 9: Model specification: Effects on the wider surrounding area

NTL intensity	(1)	(2)	(3)	(4)
Connection × Access point ∈ (0km, 10km]	0.154***	0.161***	0.137**	0.124**
	(0.0538)	(0.0552)	(0.0528)	(0.0609)
Connection × Access point ∈ (10km, 25km]	0.0809	0.0785	0.0678	0.110
	(0.0774)	(0.0691)	(0.0642)	(0.0705)
Connection × Access point ∈ (25km, 50km]	0.0589	0.0686	0.0611	0.0854
	(0.0554)	(0.0558)	(0.0551)	(0.0606)
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
R^2	0.938	0.938	0.939	0.927
Town FE	×	×	×	×
Country × Year FE	×	×	×	×
Mobile coverage (GSM)		×	×	×
Market access		×	×	×
Geographic controls			×	×
Restriction	10km	10km	10km	50km

Notes: NTL intensity is measured as the log 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 2. Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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.7), the population threshold for nodal cities (Appendix Tables C.8 and C.9), and the distance threshold for nodal cities (Appendix Table C.10) and the capital city specifically (Appendix Table C.11). Furthermore, we use other sources of NTLs (Appendix Table C.13), e.g., from Bluhm and Krause (2022), and re-estimate our baseline model while relaxing the requirement of yearly town-level NTL emissions (Appendix Tables C.14 and C.15). All robustness checks are extensively discussed in the dedicated Appendix C. They show the robustness of the results with respect to measurement choices.

Omitted variables. To control for time-varying local infrastructure, we have data on the rollout of mobile coverage and changes in market access. First, we account for time lags in improved mobile connectivity as potential omitted variables affecting economic activity (Appendix Table D.38). Results show that the main effect remains robust in all specifications. Second, we show alternative constructions of the market access control, by varying the base year for the population and by allowing for population changes in the market access measure (Appendix Table D.39). Across all specifications, the results remain unchanged.

Electricity is often found to be 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 and the question of whether the dwelling has electricity. Across all specifications, the estimated effect of internet availability on household electricity access is near zero and statistically insignificant, providing no evidence of a systematic overlap in the rollout of electricity and internet infrastructure. Additionally, we construct an alternative treatment indicator, which is one if the household is on the electricity grid, and interact it with the countrywide internet connection indicator again. Electricity grid coverage is defined based on the earliest available data (2007) from AICD (2007). Hence, for some countries, the electricity grid data precedes internet connection; for others, internet access was introduced earlier. Appendix Table D.41 shows that the internet connection is not related to a higher share of households receiving electricity access, either through proximity to the national internet backbone or to the electricity grid.

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 permute 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. Appendix Figure E.15 plots the estimated placebo coefficients against their empirical CDF. None of the placebo coefficients is larger, increasing the evidence that the estimated effect is statistically significant, at least at the 1% level. Similarly, we conduct a second placebo exercise, randomly allocating the countrywide connection years (Appendix Figure E.16). As only earlier connection years are assigned and we are limited in the pre-treatment periods by the NTL data, we allow for NTL emissions starting two years earlier (from 1993). Only two placebo coefficients are larger, increasing the evidence that the estimated effect is statistically significant at the 1% level. Moreover, the placebo tests show that the captured effect indeed originates from early internet availability.

External validity. Thus far, we have focused on restricted samples to ensure cleaner comparisons, albeit at the cost of sample size. We now demonstrate that the results also hold when relaxing assumptions and expanding the number of countries included. First, Appendix Table C.16 step-wise removes nodal cities without limiting the sample to countries used in the main specification, allowing estimations on up to 18 countries. Similarly, we apply the population thresholds to a broader set of countries (Appendix Tables C.17 and C.18). Next, we repeat the staggered treatment specifications, where up to 22 countries can be included (Appendix Table C.19). Corresponding event study plots using both TWFE and the estimator by Sun and Abraham (2021) are shown in Figures C.1, C.2, C.3, and C.4. Finally, relaxing the fixed effects allows us to compare across 21 countries. Instead of countries, we interact the year fixed effects with continental regions (Appendix Table C.20). All specifications are discussed in detail in Appendix C, and the results remain robust when including a broader set of countries.

8. Conclusion

Digital infrastructure is a key precondition for internet availability, yet its provision remains challenging in many areas of SSA, particularly outside major cities, where remoteness and low population density increase costs. It is not obvious whether mid-sized towns in these areas are positioned to benefit substantially 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, improves the economic development of remote towns.

We find that the early internet access of remote towns in SSA, on average, leads to an increase in their NTL intensity of 10.4%, relative to similar towns not yet having internet access. This translates into about 3.10 pp higher growth in terms of GDP. Decomposing NTL emissions into extensive and intensive margins and assessing changes in population, we find evidence for increases in per-capita output rather than a spatial redistribution of economic activity. Using individual-level georeferenced DHS, we find employment effects of early internet availability of 10.9 pp. Disaggregated results reveal that these effects are concentrated among

women and individuals without higher education, primarily in agriculture and unpaid work, suggesting that increased per-capita output likely stems from increased employment rather than increased productivity. At the same time, individuals with higher education experience increases in formal employment. Internal migration patterns show that while internet availability leads to out-migration of residents with higher education in treated towns, recently in-migrants also have a higher educational level.

We explore potential mechanisms. Using OSM data, we find that the presence of cybercafés increases overall employment, particularly for women and those without higher education. Restaurants show similar effects, consistent with the interpretation of cybercafés as "third places" that foster informal interaction. Other local amenities do not exhibit comparable impacts, underscoring the distinct role of cybercafés for employment effects. Moreover, we find suggestive evidence from Zambia's *FinScope* surveys that internet availability increases access to formal financial services, pointing to a complementary channel for paid employment and potentially also for employment in services.

Our findings have relevant implications for policymakers. Importantly, internet infrastructure drives economic development in remote towns beyond the large urban areas of developing countries. Moreover, our findings point to economic effects even with internet availability at basic speeds and through a low-cost and community-based access mode before the mobile internet era.

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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.[69]

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.[70] 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).[71]

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

Appendix A.2. Market access

We construct a time-varying measure of market access using road network data from Jedwab and Storeygard (2022). The measure is defined as:

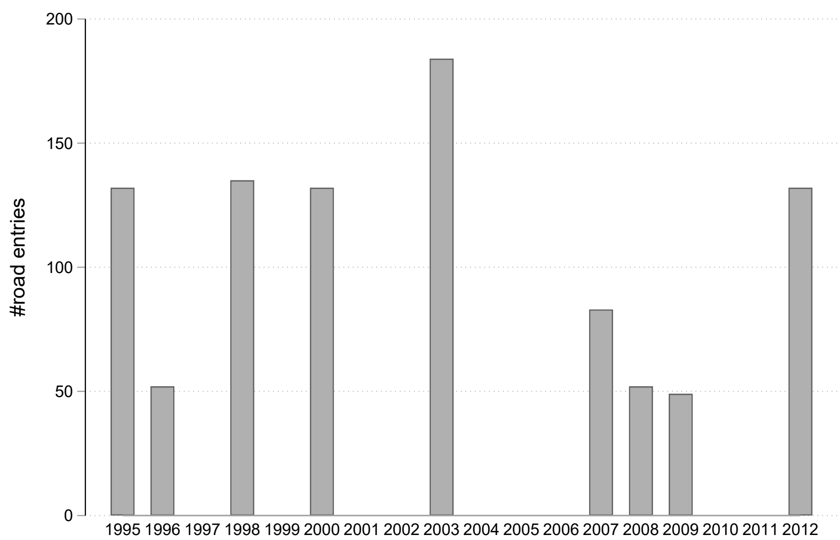
$$\text{MA}_{it}^{2000} = \sum_{j \neq i} \frac{pop_j^{2000}}{\omega_{ijt}^{\theta}}, \tag{A.1}$$

where pop_j^{2000} is the population of destination town or city j in the year 2000 (sourced from *Africapolis*), and ω_{ijt} is the travel time from the origin town i in year t.[72] We follow Jedwab and Storeygard (2022) in setting the distance elasticity θ to take the value of 3.8.

Because road network data is not available for every year, we impute values of MA_{it}^{2000} for missing years. Between 1995 and 2012, road data is available for five to six years in all countries, and for most countries, three of those years fall within the estimation period of eleven years. Only for Sudan and Mozambique, only two years of road data is available.

Figure A.1 presents the number of road data entries from Jedwab and Storeygard (2022) across years for the 184 towns in the estimation sample. While full coverage is available in 2003, surrounding years (2001 and 2002 and 2004 through 2006) lack road data, meaning that in this period market access only changes if it is allowed for population changes.[73] In the early years (1995 through 2000) and later years (2007 through 2012), at least some countries have road data entries in approximately every second year.

Figure A.1: Road data availability over time

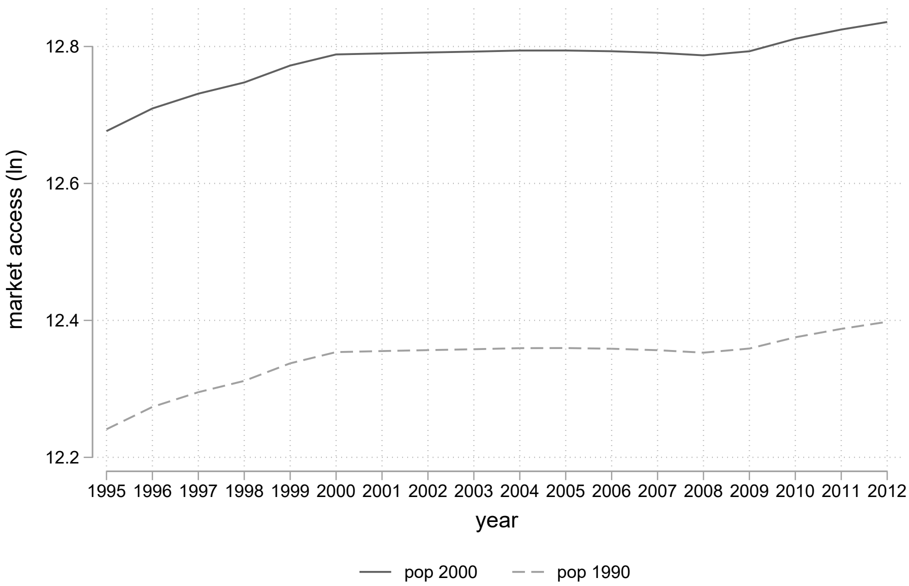


Notes: The figure presents the number of road data entries from Jedwab and Storeygard (2022) over time for the 184 towns in the estimation sample.

[72]We take values from the year 2000 as we do it for the population threshold.
[73]This is implemented as a robustness check in Table D.39 (Columns 3 and 4).

In Table D.39 (Column 2), we calculate MA_{it}^{1990} as a further robustness check, using population values from 1990 to ensure that the market access measure is not affected by post-treatment population changes. However, this comes at the cost that more towns have zero population values in the 1990 *Africapolis* data. Figure A.2 depicts the time trends of both measures for the 184 towns in the estimation sample. While both follow similar trajectories, the 1990-based measure is consistently lower due to smaller population figures in that year. Between 2000 and 2009, both measures remain almost stable, whereas large improvements are observed between 1995 and 2000, and again after 2009.

Figure A.2: Changes in market access over time (fixed population)

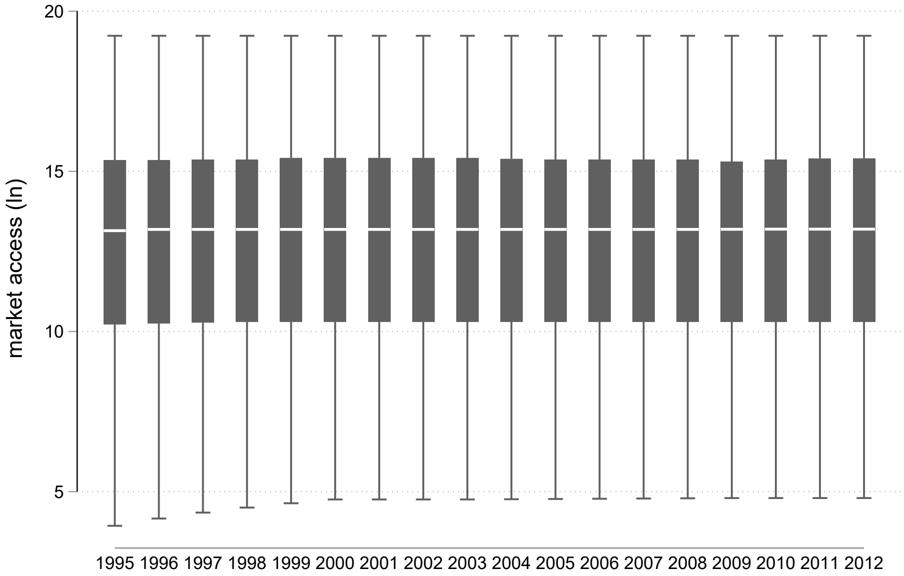


Notes: The figure shows the evolution of two market access measures with fixed population over time for the 184 towns in the estimation sample. The dashed line uses 1990 population data from *Africapolis*, while the solid line uses population data from 2000.

Figure A.3 presents box plots by year, which provide a clearer view of the distribution of MA_{it}^{2000} over time. Improvements are most pronounced for towns with low levels of market access. While there is a slight increase for the median town, further improvements are not visible at the upper end of the distribution.

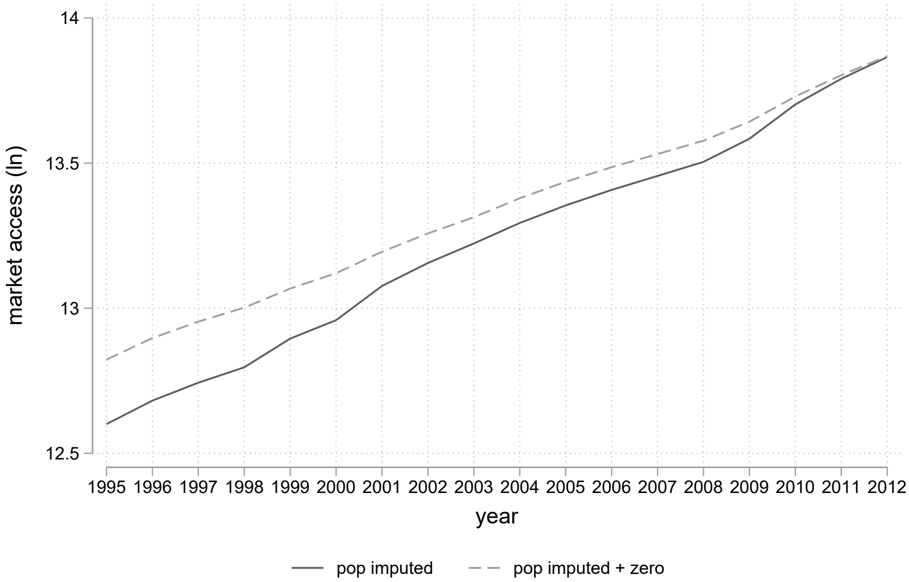
We also construct two alternative market access measures that incorporate population changes over time. First, we use all available population data from *Africapolis* (1990, 2000, 2010, and 2015) and impute values for the years in between. We then use this population measure to calculate an alternative market access measure. Second, we refine this measure by replacing zero population entries with the first positive value available for each town in *Africapolis*. These two approaches introduce greater variation in market access over time (Figure A.4). However, unlike the baseline specification, the resulting control reflects not only changes in transportation infrastructure, due to altered travel times, but also shifts in population distribution.

Figure A.3: Box plot for MA_{it}^{2000}



Notes: The figure presents a box plot for each year from 1995 to 2012, showing the distribution of the market access measure based on 2000 population data from *Africapolis*, for the 184 towns in the estimation sample.

Figure A.4: Changes in market access over time (varying population)



Notes: The figure shows the evolution of two market access measures with time-varying population for the 184 towns in the estimation sample. The solid line uses *Africapolis* population data whereas the dashed line represents the same measure, but with zero population values replaced by the first available positive value from *Africapolis*.

Appendix B. Supplemantary information

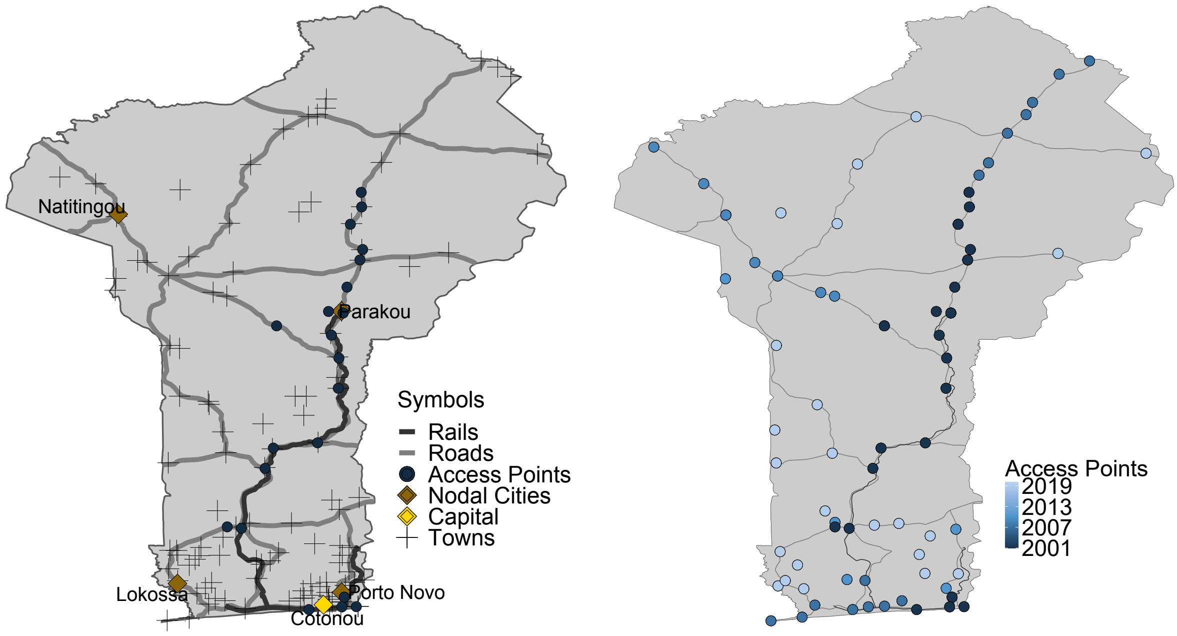
Appendix B.1. Country example: Benin

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. Nearby, 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 optical-fiber cable was constructed in 2001. Parakou is Benin's next largest economic center, with more than 150,000 inhabitants in the 2002 census, and the capital city of the Borgou department. This connection was constructed along Benin's railway line and road network (Panel a of Figure B.1). 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.1). 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.1). 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.1). 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 via 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%) or at the workplace (2.2%), 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.

Figure B.1: 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.

In contrast to international institutions, universities, or major corporations, private individuals typically do not have home access (Chabossou, 2007). Still, in 2006, only 25% of Benin's population had used the internet at least once.

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; Furuholt and Kristiansen, 2007). Beyond online interactions, cybercafés also served a social function offline by bringing users together in a shared physical space (Sairosse and Mutula, 2004; Boase et al., 2003). Cybercafés are considered places to learn ICT and acquire new skills, especially through the support of employees who provide assistance (Haseloff, 2005; Sairosse and Mutula, 2004). As Cilesiz (2009) notes, these "technosocial spaces" (Lægran and Stewart, 2003) fostered learning in informal settings.

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 (Furuholt and Kristiansen, 2007; Mwesige, 2004; Sairosse and Mutula, 2004). In a 2003 survey in Uganda, users indicated the purposes of their internet use in cybercafés are communication via e-mail (89%), research (32%), entertainment (30%), education (27%), or sports and news (24%); a quarter of respondents indicated using the internet for trade and commerce (Gitta and Ikoja-Odongo, 2003).

According to Williams et al. (2012), cybercafés are particularly important for rural internet access in Africa as they benefit small-scale knowledge-based businesses such as call centers, engineering companies, farmers, and other local firms relying on outside information. Furthermore, cybercafés offer additional services connected to computers and ICT, such as printing or photocopying (LeBlanc and Shrum, 2017; Sairosse and Mutula, 2004). 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 internet-enabled mobile phones, an alternative to the "long queues, overstuffed rooms, [and] lack of privacy" in cybercafés was established (Quadri, 2023). At the same time, cybercafés offered advantages that mobile internet could not easily replicate. They enabled shared use, provid-

ing access for individuals without personal devices, and functioned as “third places” where people gathered, exchanged information, and used the internet collectively. By contrast, mobile internet is inherently individualized and private. 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

Near versus far. To address concerns that towns located on different road networks might differ systematically in unobserved characteristics, we implement two alternative identification strategies that compare towns along similar infrastructure corridors. First, we instrument a town's likelihood of receiving internet access using its distance to a minimum spanning tree (MST) connecting nodal cities at the time of countrywide internet connection. This approach follows Faber (2014) and assumes that proximity to the national backbone increases the probability of receiving internet access, while being plausibly exogenous to local economic trends.

To construct the instrument, we first define the MST using the set of nodal cities in each country at the year of the countrywide internet connection. We then measure each town's nearest distance to the MST. Thus, the instrument is time-invariant. In addition to excluding nodal cities, we apply two further restrictions to ensure comparability: (i) consistent with the main specification, we exclude towns that receive an access point during the post-treatment period, to avoid contamination of the control group, and (ii) we exclude towns within 50 kilometers of an access point in the connection year, as they might benefit directly or indirectly through spillovers (Table 9). These restrictions yield a sample of 229 towns.

Following Faber (2014), we employ a long-difference specification, comparing NTL emissions before and after the internet connection, while instrumenting internet access with distance to the MST. The first stage is specified as follows:

$$Access_{is(i)} = \lambda_1 \text{MST distance}_i + \lambda_2 \text{GSM}_i + \lambda_3 \text{MA}_i^{2000} + \mathbf{X}_i' \lambda_4 + \kappa_{s(i)} + \nu_{is(i)}, \tag{C.1}$$

where MST distance_i denotes the time-invariant distance of town i to the MST and serves as the instrument. We control for the same covariates as in Table 2 (Column 3): Distances are taken in their time-invariant way ($\mathbf{X}_i$), while mobile coverage (GSM_i) and market access (MA_i^{2000}) are taken from the year preceding the countrywide internet connection. State fixed effects $\kappa_{s(i)}$ are included to account for regional heterogeneity. Since control group towns in this specification might never receive an access point, we cluster standard errors using the spatial correction proposed by Conley (1999) to account for potential spatial correlation across nearby towns.

The second stage use predicted internet access $\widehat{\text{Access}}_{is(i)}$ from the first stage (Equation C.1) and is specified as follows:

$$\Delta Y_{is(i)} = \eta_1 \widehat{\text{Access}}_{is(i)} + \eta_2 \text{GSM}_i + \eta_3 \text{MA}_i^{2000} + \mathbf{X}_i' \eta_4 + \varphi_{s(i)} + \upsilon_{is(i)}, \tag{C.2}$$

where $\Delta Y_{is(i)}$ is the long difference in economic activity.

Results are presented in Columns (1) and (2) of Table C.1. The first stage estimate indicates that doubling the distance from the MST reduces the probability of receiving internet access

by about 11%. The instrument is highly statistically significant, and the corresponding F-statistic in Column (2) confirms its relevance. The second stage estimate (2SLS) in Column (2) is statistically significant and shows a larger effect of internet availability on local economic development than in the baseline. Importantly, because this specification compares geographically proximate towns that differ primarily in their access to the internet, the estimated effect might also capture localized economic reallocation, i.e., economic activity shifting from unconnected to connected towns.

Table C.1: Model specification: Instrumental variable and triple-differences specifications

NTL intensity	(1) First Stage	(2) 2SLS	(3) Near vs. far (early)	(4) Near vs. far (late)	(5) DDD
MST distance (ln)	-0.111***				
	(0.0270)				
Access		0.395**			
		(0.196)			
Connection × Access			0.205***	-0.0444	
			(0.0690)	(0.0712)	
Connection × Access × Early					0.369***
					(0.113)
Observations	229	229	429	264	693
#Countries	10	10	4	4	4
#Towns	229	229	39	24	63
#States	52	52	16	17	31
F stat	–	14.981			
R^2	0.838	–	0.949	0.948	0.947
State FE	×	×			
Town FE			×	×	×
Country × Year FE			×	×	
Country × Early × Year FE					×

Notes: The table presents alternative identification strategies (IV and DDD). NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Same towns and geographic controls as in Table 2 (Column 3). Conley (1999) standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

To further address concerns about endogenous placements of access points and unobserved differences between roads, we, second, implement a triple-differences (DDD) approach. Specifically, we restrict the sample to towns on the roads of the initial rollout and compare the difference in outcomes between towns with and without an access point to the same difference observed for towns along roads that the rollout followed later. This approach ensures that treated towns are not compared to towns in the control group that are far away or located on less important roads. The same restrictions as above apply: Control group towns must not (i) be nodal cities, (ii) receive an access point during the post-treatment period, and (iii) be located within 50 kilometers from an access point in the connection year. However, in contrast to the main specification, they are not required to receive an access point at a later point in time. As this approach compares towns with and without an access point, both near the

initially rolled-out and the later rolled-out backbone segments, the sample is limited to four countries where such comparisons are possible (Angola, Ethiopia, Zambia, and Zimbabwe). The DDD is specified as follows:

$$\begin{aligned} Y_{ic(i)t} = \psi_0 + \psi_1\big(\text{Connection}_{c(i)t} \times \text{Access}_i \times \text{Early}_i\big) + \psi_2\big(\text{Connection}_{c(i)t} \times \text{Access}_i\big) \\ + \psi_3\big(\text{Connection}_{c(i)t} \times \text{Early}_i\big) + \psi_4 \text{GSM}_{it} + \psi_5 \text{MA}_{it}^{2000} + \big(\mathbf{X}_i' \times \text{Connection}_{c(i)t}\big)\psi_6 \\ + \sigma_i + \sigma_{c(i)t} + \text{Early}_i' \sigma_t + \vartheta_{ic(i)t}, \end{aligned} \tag{C.3}$$

where Early_i indicates whether town i is located on a road included in the initial backbone roll-out. The model includes town fixed effects (σ_i) and interactions between Early_i and country-year fixed effects to control for time-varying shocks that differ across initially and later rolled-out backbone segments. The same control variables as in the main specification apply. All required first- and second-order interaction terms required for identification of the triple-difference estimator are included in the specification or absorbed by the fixed effects. As in the IV specification, control group towns may not be located near an access point. We use Conley (1999) standard errors to account for spatial correlation.

The results are presented in Columns (3) through (5) of Table C.1. The identifying assumption is that the difference between towns with and without an access point at roads followed *later* by the rollout is a good counterfactual for how the difference between towns with and without an access point at roads followed *earlier* by the rollout would have evolved in the absence of the countrywide internet connection. We thus start by showing DiD estimates for earlier and later regions separately. We find a positive and statistically significant coefficient for the earlier connected roads (Column 3) and a coefficient that is close to zero and lacks statistical significance for later connected roads (Column 4), suggesting that early internet rollout indeed had a distinct impact. In Column (5), we show the DDD estimate, which is similar in magnitude to the 2SLS estimate (Column 2) and also statistically significant. This finding supports the interpretation that economic activity shifts toward connected towns along prioritized road networks and provides additional credibility to our identification strategy.

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.2, 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 2), 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.[74] 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.[75] 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.

[74] Angola is dropped. The estimate of the main specification without Angola is 0.0810 (SE 0.0308). In Table C.3, 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% level. The only notable exception is a larger *upward* deflection when Ethiopia is excluded.

[75] Angola and Malawi are dropped.

Table C.2: Model specification: Robustness to further restrictions

NTL intensity	(1)	(2)	(3)	(4)	(5)
Connection × Access	0.0995**	0.0748**	0.0966**	0.110***	0.114***
	(0.0441)	(0.0331)	(0.0421)	(0.0387)	(0.0391)
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
R^2	0.948	0.936	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 speed was increased due to upgraded SMCs (Column 4), and ethnic favoritism (Column 5). NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 2 (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.3: Robustness to single country exclusions

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Connection × Access	0.104***	0.0810***	0.0962**	0.108***	0.169***	0.105***	0.110***	0.0960**	0.0913**	0.110***	0.0818**
	(0.0374)	(0.0308)	(0.0442)	(0.0379)	(0.0473)	(0.0389)	(0.0388)	(0.0379)	(0.0414)	(0.0397)	(0.0385)
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
R^2	0.939	0.941	0.944	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 log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 2 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Country restrictions. To ensure that our results are not driven by individual towns in countries with limited within-country variation, we conduct robustness checks that exclude countries with only one or two treated or control towns. In particular, Angola and Sudan each have only one treated town in our sample, as they had only just begun their national backbone rollouts when the submarine cable connection occurred. Botswana, by contrast, has only one control town, having already rolled out much of its national backbone prior to the establishment of its countrywide internet connection. Malawi presents a similar concern, with only two treated towns and a total sample of eight towns.

In such cases, concerns arise that estimates might be driven by outliers, i.e., a single treated or control town experiencing an unrelated economic boom or bust. With only one treated or control group town per country, the estimate could be highly sensitive to idiosyncratic shocks in that specific town rather than reflecting a generalizable treatment effect. Moreover, in small samples, the treatment effect might appear statistically significant by chance, particularly if town characteristics differ in unobserved ways.

To address this, we systematically exclude these countries in a series of robustness checks reported in Table C.4. The results remain robust across specifications: excluding Angola and Sudan (Column 2), or additionally Malawi (Column 3), or Botswana (Column 4), or all but Malawi (Column 5), or all four countries (Column 6). While point estimates shrink modestly when excluding countries with only one or two treated towns, they remain statistically significant at the 5% level. When excluding Botswana, the only country with a single control town, the estimate remains virtually unchanged.

Table C.4: Robustness to excluding countries with single towns in treatment or control group

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)
Connection × Access	0.104***	0.0729**	0.0736**	0.108***	0.0763**	0.0774**
	(0.0374)	(0.0312)	(0.0324)	(0.0379)	(0.0317)	(0.0329)
Observations	2,024	1,826	1,738	1,914	1,716	1,628
#Countries	10	8	7	9	7	6
#Towns	184	166	158	174	156	148
Share treated	0.484	0.524	0.538	0.46	0.5	0.514
R^2	0.939	0.942	0.943	0.933	0.936	0.936
Town FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×
Countries	all	>1 treated town	>2 treated towns	>1 control town	>1 treated & >1 control town	>2 treated & >2 control towns

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

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 2 with town and country-ethnicity-year 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.2. Naturally, sample size reduces in this more demanding specification to 132 towns in nine countries.[76] The result remains robust, showing that even when comparing treatment and control group towns in areas with the same ethnic group majority, early internet availability has a positive effect on local economic development.

[76] 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.

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 9). To account for this, we apply a higher level of clustered standard errors in Columns (3) and (4) of Table C.5 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.5: Model specification: Robustness to clustering at different levels

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Connection × Access	0.104***	0.104***	0.104***	0.104**	0.104***	0.104***	0.104**	0.104**
	(0.0374)	(0.0368)	(0.0366)	(0.0396)	(0.0371)	(0.0391)	(0.0420)	(0.0428)
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 2. All else equal to Table 2 (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 log distance to the capital city. However, it might be the case that this relationship is actually linear, quadratic, or cubic (Table C.6, Columns 2 through 4). In fact, we show that with these specifications, the estimate increases slightly, making our preferred specification with the log distance more credible.

Table C.6: Model specification: Robustness to specifications of the capital city distance

NTL intensity	(1)	(2)	(3)	(4)
Connection × Access	0.104***	0.115***	0.117***	0.113***
	(0.0374)	(0.0396)	(0.0391)	(0.0392)
Observations	2,024	2,024	2,024	2,024
R^2	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 log implementation of the distance to the capital city, based on the main specification in Equation 2. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Sample, i.e., towns, and controls as in Table 2 (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.[77] 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 0, 5, 7.5, 12.5, 15, 20, and 50 kilometers for robustness in Table C.7. Note that the distance threshold affects the sample. Specifically, when allowing for higher distances, the control group share shrinks and the sample increases.[78] 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 until 20 kilometers (Columns 1 through 7). For a threshold of 50 kilomters, we find a similarly sized estimate that is less precisely estimated as also towns without internet access are contained in the treatment group in this specification (Column 8). The slight reductions in point estimates and statistical power for other thresholds than 10 kilometers suggest that our preferred specification is appropriate.

Table C.7: Measurement: Robustness to access point distance thresholds

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Connection × Access	0.0988**	0.0805**	0.0975**	0.104***	0.0857**	0.0838**	0.0922**	0.0885
	(0.0434)	(0.0370)	(0.0403)	(0.0374)	(0.0394)	(0.0387)	(0.0408)	(0.0576)
Observations	1,342	1,705	1,914	2,024	2,101	2,112	2,189	2,013
#Countries	9	9	10	10	10	10	10	8
#Towns	122	155	174	184	191	192	199	183
Share treated	0.443	0.445	0.448	0.484	0.518	0.536	0.543	0.639
R^2	0.952	0.942	0.938	0.939	0.938	0.938	0.933	0.918
Town FE	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×
Access point distance	0km	5km	7.5km	10km	12.5km	15km	20km	50km

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

[77] 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. Our analysis in Section 3 supports this choice.

[78] Only for a threshold of 50 kilometers, two countries are dropped as the control group diminishes.

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.[79] In Tables C.8 and C.9, we present robustness checks regarding the population threshold for nodal cities. In Table C.8, 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.9 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% of towns are dropped. The effect remains when even the larger half of towns is removed (Column 6).

Table C.8: Measurement: Robustness to absolute population thresholds

NTL intensity	(1)	(2)	(3)	(4)	(5)
Connection × Access	0.127***	0.118***	0.104***	0.0998***	0.0951***
	(0.0394)	(0.0375)	(0.0374)	(0.0347)	(0.0346)
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
R^2	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 2. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 2 (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.10). 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.11), where we consider specifications in which towns up to 150 kilometers away from the capital city are excluded. We choose a larger

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

Table C.9: Measurement: Robustness to relative population thresholds

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)
Connection × Access	0.0891***	0.0989***	0.115***	0.122***	0.127***	0.132***
	(0.0338)	(0.0350)	(0.0366)	(0.0393)	(0.0433)	(0.0441)
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
R^2	0.962	0.947	0.938	0.933	0.925	0.925
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 2. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 2 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

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.10: Measurement: Robustness to nodal city distance thresholds

NTL intensity	(1)	(2)	(3)	(4)
Connection × Access	0.104***	0.0990**	0.0924**	0.0994*
	(0.0374)	(0.0381)	(0.0437)	(0.0520)
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	0.948
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 2. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 2 (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.12). 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% level.

Table C.11: Measurement: Robustness to capital city distance thresholds

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Connection × Access	0.104***	0.113***	0.0889***	0.0995***	0.0977***	0.0928**	0.0914**
	(0.0374)	(0.0406)	(0.0321)	(0.0332)	(0.0338)	(0.0357)	(0.0376)
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	0.941	0.935	0.945	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 2. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 2 (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 step-wise removing nodal cities

NTL intensity	(1)	(2)	(3)	(4)	(5)
Connection × Access	0.0683**	0.0726**	0.0687**	0.0891***	0.104***
	(0.0305)	(0.0330)	(0.0321)	(0.0338)	(0.0374)
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 2. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 2 (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.13, 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.

Table C.13: Measurement: Robustness to other NTL sources and procedures

	(1) Harmonized	(2) Topcoded	(3) Stable	(4) Average
Connection × Access	0.104***	0.104***	0.103***	0.0902**
	(0.0374)	(0.0378)	(0.0378)	(0.0397)
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 2. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Same towns and controls as in Table 2 (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 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.14, 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 2). 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.15, which improves the statistical power of the estimates in comparison to Table C.14. 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.14: Measurement: Robustness to ignoring missing NTL years

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Connection × Access	0.100**	0.107***	0.0842**	0.0611	0.104***	0.0964**	0.0883**	0.0875**
	(0.0445)	(0.0386)	(0.0382)	(0.0402)	(0.0374)	(0.0401)	(0.0430)	(0.0432)
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 2. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 2 (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.15: Measurement: Robustness to imputing missing NTL years

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Connection × Access	0.100**	0.101**	0.0971**	0.0971**	0.104***	0.0936**	0.0943**	0.0899**
	(0.0445)	(0.0445)	(0.0438)	(0.0438)	(0.0374)	(0.0418)	(0.0442)	(0.0442)
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 2. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 2 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

External validity. We relax the sample selection criteria to demonstrate that our results are robust when including a broader set of countries. First, we re-estimate Table C.12, which tests the robustness of our findings to the step-wise removal of nodal cities, without limiting the analysis to the countries used in the main specification (Table 2). Table C.16 confirms that the results are robust when the sample is expanded. Without restricting nodal cities, 18 countries are in the analysis (Column 1). However, in five of these, only the landing point city enters the treatment group, which leads to comparisons between a single treated city and many control group cities and towns. When removing the landing point city as only nodal city and restricting to countries with at least one city or town in the treatment and the control group, respectively, thirteen countries remain (Column 2). Removing capital cities does not further reduce the number of countries (Column 3). However, when regional capital cities are removed, the same ten countries remain as in Table C.12 (Column 4).

Table C.16: External validity: Robustness to step-wise removing nodal cities

NTL intensity	(1)	(2)	(3)	(4)	(5)
Connection × Access	0.0570**	0.0679**	0.0664**	0.0891***	0.104***
	(0.0283)	(0.0313)	(0.0302)	(0.0338)	(0.0374)
Observations	6,435	3,168	3,091	2,310	2,024
#Countries	18	13	13	10	10
#Towns	585	288	281	210	184
Share treated	0.289	0.549	0.537	0.514	0.484
R^2	0.964	0.969	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 2. It is not restricted to the countries in the main specification. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 2 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Next, we re-estimate Tables C.8 and C.9, which present robustness checks to the absolute and relative population threshold for nodal cities, without restricting the sample to the countries included in the main analysis (Table 2). As shown previously, the number of countries drops already to ten when regional capital cities are excluded. Therefore, in Tables C.17 and C.18, we include regional capital cities to retain a broader country sample. The results remain robust.

Table C.17: External validity: Robustness to absolute population thresholds

NTL intensity	(1)	(2)	(3)	(4)	(5)
Connection × Access	0.115***	0.114***	0.0975***	0.0910***	0.0879***
	(0.0363)	(0.0353)	(0.0337)	(0.0311)	(0.0312)
Observations	1,903	2,156	2,343	2,673	2,761
#Countries	11	11	11	13	13
#Towns	173	196	213	243	251
Share treated	0.486	0.48	0.488	0.498	0.514
R^2	0.921	0.931	0.937	0.945	0.949
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 2. Regional capital cities are included. It is not restricted to the countries in the main specification. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 2 (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.18: External validity: Robustness to relative population thresholds

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)
Connection × Access	0.0664**	0.0938***	0.107***	0.107***	0.115***	0.136***
	(0.0302)	(0.0319)	(0.0340)	(0.0357)	(0.0390)	(0.0404)
Observations	3,091	2,761	2,343	1,958	1,639	1,353
#Countries	13	13	12	10	10	10
#Towns	281	251	213	178	149	123
Share treated	0.537	0.498	0.479	0.494	0.503	0.504
R^2	0.961	0.949	0.936	0.927	0.921	0.922
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 2. Regional capital cities are included. It is not restricted to the countries in the main specification. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Table 2 (Column 3). Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The strongest change to the sample composition is allowed when relaxing the condition that, within each country, at least one town must have received an access point before the country-wide internet connection and at least one town must have received one after the observation period. First, we relax this condition by re-estimating Table 8, which defines internet availability at the town level based on access point construction, without restricting the sample to the countries in the main analysis (Table 2). In Table C.19, between 21 and 22 countries are included, covering more than 500 towns. The results remain robust, with estimates about 1 to 4 pp lower than in Table 8.[80]

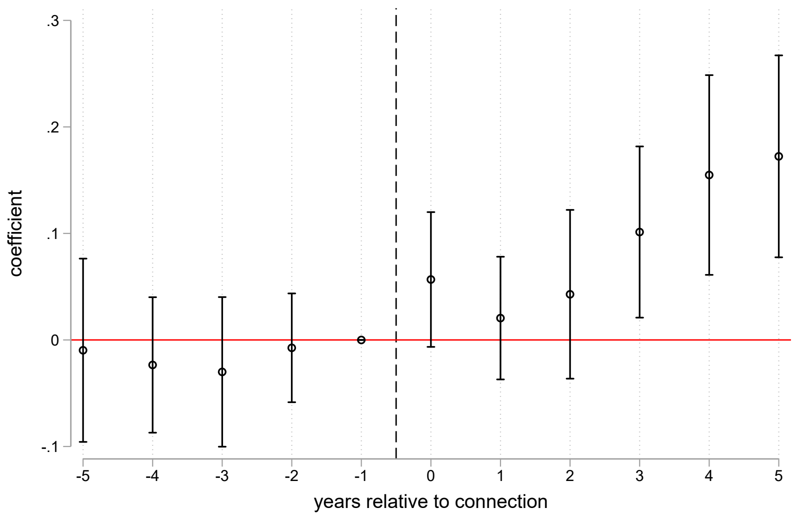
Table C.19: External validity: Staggered treatment

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)
Internet availability	0.0656**	0.0656**	0.0606**	0.0577**	0.0581**	0.0555**
	(0.0264)	(0.0264)	(0.0256)	(0.0251)	(0.0251)	(0.0243)
Observations	5,803	5,803	5,803	5,548	5,548	5,548
#Countries	22	22	22	21	21	21
#Towns	529	529	529	506	506	506
Share treated	0.465	0.465	0.465	0.581	0.581	0.581
R^2	0.918	0.918	0.918	0.917	0.917	0.918
Town FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×
Mobile coverage (GSM)		×	×		×	×
Market access		×	×		×	×
Geographic controls			×			×
Post-treatment period	×	×	×			
Before speed upgrade period				×	×	×

Notes: NTL intensity is measured as the log 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. It is not restricted to the countries in the main specification. Geographic controls as basic geographic controls in Column (3) of Table 2. Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

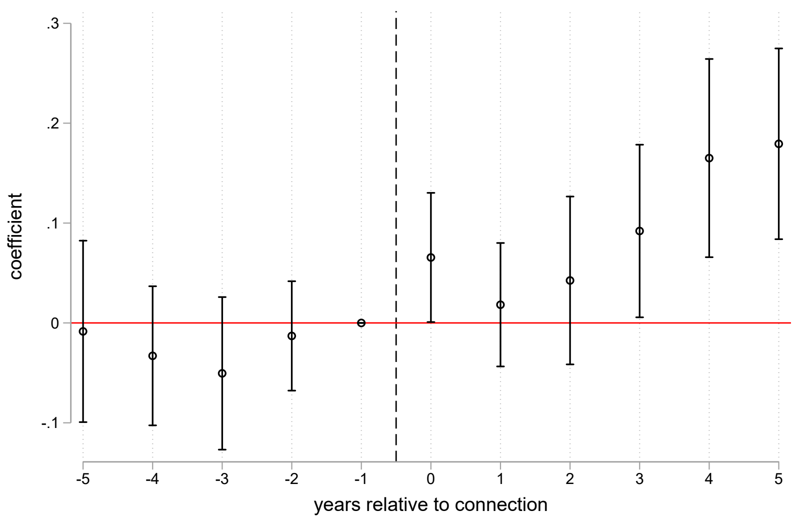
[80] As before, we re-estimate these results using the estimator by Sun and Abraham (2021). The event study corresponding to Column (3) of Table C.19 is shown in Figure C.1, while the event study corresponding to Column (6) of Table C.19 is shown in Figure C.2. For comparison, the corresponding event studies using TWFE are shown in Figures C.3 and C.4, respectively. In all cases, the results remain robust.

Figure C.1: External validity: Staggered treatment (Sun and Abraham, 2021) I



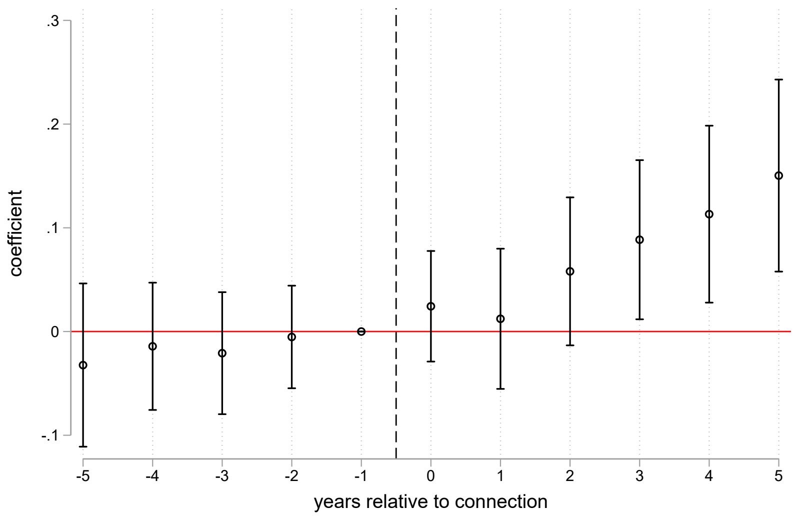
Notes: The figure presents the event study coefficients based on the estimator proposed by (Sun and Abraham, 2021) and corresponding to Table C.19 (Column 3). The outcome is NTL intensity, measured as the log sum of NTL intensities, on the *Africapolis* built-up area with a 2-kilometer buffer. Confidence intervals are drawn at the 95% level using standard errors clustered at the level of the closest access point.

Figure C.2: External validity: Staggered treatment (Sun and Abraham, 2021) II



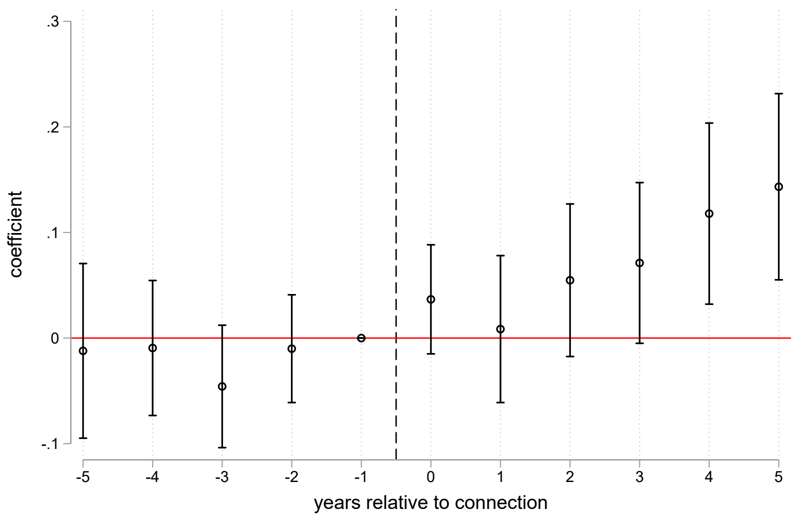
Notes: The figure presents the event study coefficients based on the estimator proposed by (Sun and Abraham, 2021) and corresponding to Table C.19 (Column 6). The outcome is NTL intensity, measured as the log sum of NTL intensities, on the *Africapolis* built-up area with a 2-kilometer buffer. Confidence intervals are drawn at the 95% level using standard errors clustered at the level of the closest access point.

Figure C.3: External validity: Staggered treatment (TWFE) I



Notes: The figure presents the event study coefficients estimated using TWFE and corresponding to Table C.19 (Column 3). The outcome is NTL intensity, measured as the log sum of NTL intensities, on the *Africapolis* built-up area with a 2-kilometer buffer. Confidence intervals are drawn at the 95% level using standard errors clustered at the level of the closest access point.

Figure C.4: External validity: Staggered treatment (TWFE) II



Notes: The figure presents the event study coefficients estimated using TWFE and corresponding to Table C.19 (Column 6). The outcome is NTL intensity, measured as the log sum of NTL intensities, on the *Africapolis* built-up area with a 2-kilometer buffer. Confidence intervals are drawn at the 95% level using standard errors clustered at the level of the closest access point.

Second, we relax the fixed effects, such that not only variation within countries is exploited. Instead of comparing within countries, we define three broader continental regions (east, west, and south) and compare within these regions. This approach expands the sample, as it only requires that both treated and control towns exist within each region, rather than within each country. The trade-off, however, is that we account only for regional-specific, rather than country-specific, growth paths. Table C.20 re-estimates the first columns of Table 2 using this regional specification. Under this specification, the sample increases to 21 countries and 384 towns.[81] The estimate increases to 0.184 in Columns (1) and (2), roughly 5 pp higher than in the corresponding columns of Table 2. It increases further in Column (3), when basic geographic controls are included, opposite to the pattern in the main results, where the estimate decreased. Finally, in Column (4), with all geographic controls included, the estimate decreases to 0.167. While still larger than the estimate in Column (4) of Table 2, the relative decline from Columns (1) or (2) mirrors the pattern observed in the main specification. Across all specifications, the estimates remain highly statistically significant.

Table C.20: External validity: Robustness to relaxed fixed effects

NTL intensity	(1)	(2)	(3)	(4)
Connection × Access	0.184***	0.184***	0.197***	0.167***
	(0.0348)	(0.0345)	(0.0401)	(0.0408)
Observations	4,220	4,220	4,220	4,220
#Countries	21	21	21	21
#Towns	384	384	384	384
Share treated	0.253	0.253	0.253	0.253
R^2	0.893	0.893	0.894	0.896
Town FE	×	×	×	×
Continental region × Year FE	×	×	×	×
GSM coverage		×	×	×
Market access		×	×	×
Basic geographic controls			×	×
All geographic controls				×

Notes: The table presents robustness checks that include a broader set of countries by relaxing the fixed effects relative to the main specification in Equation 2. The sample is not restricted to the countries in the main specification. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Basic and all geographic controls as in Table 2, Columns (3) and (4), respectively. Standard errors are clustered at the level of the closest access point and reported in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

[81] Countries that are missing are Namibia, Djibouti, Central African Republic, Guinea-Bissau, Lesotho, and Eswatini.

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
Market access, 1990 (ln)	12.35	3.58	2.56	9.75	12.78	15.09	18.88	184
Market access,2000 (ln)	12.79	3.40	4.78	10.30	13.19	15.37	19.23	184
Market access, pop, zero (ln)	13.32	3.14	5.36	11.09	14.09	15.53	19.27	184
Market access, pop (ln)	13.22	3.17	5.12	10.83	13.95	15.53	19.27	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 south-eastern 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
Ethiopia	ETH	DJI	2007	network centered around capital and limited in Eastern regions	

Table continues on the next page.

Country	ISO	Via	Year	National backbone	Notes
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
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	

Table continues on the next page.

Country	ISO	Via	Year	National backbone	Notes
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 pre-existing powerlines to establish an unusually dense network
Zimbabwe	ZWE	ZAF	2004	network expansion covers larger cities and connections to border points	

Sources: Table F.1, 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: Internet usage

Internet usage	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Internet availability	0.0307***	0.0652***	0.0215*	0.0533***	0.0378***	0.0711***	0.0369***	0.0673***
	(0.0106)	(0.0148)	(0.0110)	(0.0183)	(0.0126)	(0.0181)	(0.0140)	(0.0197)
Observations	12,048	12,048	12,048	12,048	5,866	5,866	5,866	5,866
#Countries	13	13	13	13	7	7	7	7
#Towns	577	577	577	577	243	243	243	243
Share treated	0.107	0.107	0.107	0.107	0.131	0.131	0.131	0.131
R^2	0.305	0.145	0.361	0.227	0.228	0.066	0.265	0.121
State FE	×	×			×	×		
Region FE			×	×			×	×
Individual level controls	×		×		×		×	
Mobile coverage	×		×		×		×	
Basic geographic controls	×		×		×		×	

Notes: The table presents estimates based on Equation 1. Internet usage (0/1) from the fourth round of *Afrobarometer*. Question Q88C ("How often do you use: The Internet?"). One if more frequent than "never". Individual-level controls: age, age squared, gender, and educational level (four categories). Basic geographic controls include the log distance to the capital city and indicators for local availability of and log distance to the next road and railroad. 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: Robustness to different buffer specifications

	(1) NTL intensity	(2) Int. margin	(3) Ext. margin	(4) NTL intensity	(5) Int. margin	(6) Ext. margin
Connection × Access	0.110***	0.0820***	0.0455	0.0811*	0.0573**	0.0817**
	(0.0397)	(0.0262)	(0.0292)	(0.0438)	(0.0251)	(0.0407)
Observations	1,892	1,892	1,892	2,211	2,211	2,211
#Countries	10	10	10	10	10	10
#Towns	172	172	172	201	201	201
Share treated	0.477	0.477	0.477	0.468	0.468	0.468
R^2	0.974	0.927	0.978	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 2 (Columns 1 through 4), intensive margin as in Table 2 (Column 5), and extensive margin as in Table 2 (Column 6). Controls as in Table 2 (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: Population density

Population density	(1)	(2)
Connection × Access	0.0195	0.0198
	(0.0188)	(0.0205)
Observations	2,024	368
R^2	0.999	0.999
Town FE	×	×
Country × Year FE	×	×

Notes: NTL intensity is measured as the log sum of NTL intensities, and population density is measured as the log 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 2 (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.7: Employment: Robustness

Employment	(1)	(2)	(3)	(4)	(5)	(6)
Connection × Access	0.104***	0.0882	0.0874**	0.0686**	0.00354	0.0496
	(0.0299)	(0.0670)	(0.0375)	(0.0318)	(0.0554)	(0.0351)
Connection × Access × Female		0.0115			0.0798	
		(0.0664)			(0.0494)	
Connection × Access × Education (high)			0.0444			0.0588
			(0.0825)			(0.0732)
Observations	4,932	4,932	4,932	5,642	5,642	5,642
#Countries	5	5	5	5	5	5
#Towns	46	46	46	52	52	52
Share treated	0.429	0.429	0.429	0.359	0.359	0.359
R^2	0.277	0.279	0.277	0.296	0.297	0.296
Region FE	×	×	×			
Town FE				×	×	×
Country × Year FE	×	×	×	×	×	×
Lifted NTL restriction				×	×	×

Notes: Employment from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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: Overview of occupations by sector

	Agriculture	Manufacturing	Services	Total
agricultural	560			560
agricultural, employee	53			53
agricultural, self-employed	186			186
clerical			54	54
clerical or sales			159	159
household and domestic			53	53
household, domestic, and services			125	125
other			1	1
professional, technical, or managerial			146	146
sales			820	820
services			68	68
skilled and unskilled manual		154		154
skilled manual		248		248
unskilled manual		118		118

Notes: The table depicts how occupations from DHS are assigned to sectors and their frequencies.

Table D.9: Frequencies of occupations by country

	Benin	Ethiopia	Malawi	Senegal	Zimbabwe	Total
agricultural	125	56	342	26	11	560
agricultural, employee			50	1	2	53
agricultural, self-employed			167	16	3	186
clerical	1	13	10	8	22	54
clerical or sales				159		159
household and domestic	7		23		23	53
household, domestic, and services	2	5		61	57	125
not currently working	107	223	468	656	209	1,663
other	1					1
professional, technical, or managerial	11	26	42	39	28	146
sales	327	72	275	106	40	820
services	17		31		20	68
skilled and unskilled manual	26			128		154
skilled manual	62	30	104		52	248
unskilled manual	28	17	53		20	118

Notes: The table depicts the frequencies of occupations from DHS by countries.

Table D.10: Employment by sector: Robustness to town fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Agriculture			Manufacturing			Services	
Connection × Access	0.126***	0.125	0.155***	-0.0396	-0.0987	-0.0480*	0.0169	0.0623	-0.0198
	(0.0438)	(0.0846)	(0.0444)	(0.0249)	(0.0637)	(0.0271)	(0.0517)	(0.0838)	(0.0645)
Connection × Access × Female		-0.00413			0.0724			-0.0567	
		(0.0805)			(0.0688)			(0.0763)	
Connection × Access × Education (high)			-0.141***			0.0379			0.147*
			(0.0454)			(0.0420)			(0.0843)
Observations	4,932	4,932	4,932	4,932	4,932	4,932	4,932	4,932	4,932
#Countries	5	5	5	5	5	5	5	5	5
#Towns	46	46	46	46	46	46	46	46	46
Share treated	0.429	0.429	0.429	0.429	0.429	0.429	0.429	0.429	0.429
R^2	0.243	0.245	0.249	0.140	0.143	0.141	0.153	0.153	0.155
Region FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×

Notes: Occupation from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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: Employment by sector: Robustness to NTL restriction

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Agriculture			Manufacturing			Services	
Connection × Access	0.107***	0.111	0.117***	-0.0143	-0.0856	-0.0202	-0.0237	-0.0217	-0.0476
	(0.0396)	(0.0754)	(0.0394)	(0.0234)	(0.0625)	(0.0259)	(0.0446)	(0.0776)	(0.0504)
Connection × Access × Female		-0.00824			0.0876			0.000384	
		(0.0743)			(0.0629)			(0.0710)	
Connection × Access × Education (high)			-0.0858*			0.0318			0.113
			(0.0478)			(0.0444)			(0.0748)
Observations	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642	5,642
#Countries	5	5	5	5	5	5	5	5	5
#Towns	52	52	52	52	52	52	52	52	52
Share treated	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359	0.359
R^2	0.244	0.244	0.247	0.130	0.135	0.131	0.162	0.162	0.163
Town FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×

Notes: Occupation from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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: The effect of early internet availability on employment by skill levels

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		High skill			Mid skill			Low skill	
Connection × Access	-0.00766	0.00537	-0.0152	0.0134	0.0826	-0.0155	0.103***	-0.0503	0.119***
	(0.0116)	(0.0300)	(0.0107)	(0.0459)	(0.0813)	(0.0511)	(0.0341)	(0.0599)	(0.0429)
Connection × Access × Female		-0.0191			-0.101			0.204**	
		(0.0288)			(0.0831)			(0.0765)	
Connection × Access × Education (high)			0.0290			0.0698			-0.0514
			(0.0377)			(0.0724)			(0.0669)
Observations	4,422	4,422	4,422	4,422	4,422	4,422	4,422	4,422	4,422
R^2	0.209	0.210	0.210	0.262	0.264	0.264	0.132	0.140	0.135
Town FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×

Notes: Occupation from DHS (0/1). Sample and controls as in Table 3 (Columns 4 through 6). 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: Early internet availability and employment by sub-sector

	(1)	(2)	(3)	(4)	(5)	(6)
		Sales			Services (domestic)	
Connection × Access	-0.00638	0.0893	-0.0349	0.0354*	-0.0253	0.0312
	(0.0418)	(0.0762)	(0.0557)	(0.0196)	(0.0291)	(0.0244)
Connection × Access × Female		-0.125*			0.0855**	
		(0.0733)			(0.0332)	
Connection × Access × Education (high)			0.0901			0.0303
			(0.0598)			(0.0439)
Observations	4,422	4,422	4,422	4,422	4,422	4,422
R^2	0.155	0.156	0.157	0.089	0.093	0.090
Town FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×

Notes: Occupation from DHS (0/1). Sample and controls as in Table 3 (Columns 4 through 6). 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: Early internet availability and payment type

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Not paid			Cash only			In kind (and cash)	
Connection × Access	0.0759**	0.0332	0.0941**	0.0297	0.143	0.0184	-0.0409	-0.0685	-0.0263
	(0.0300)	(0.0848)	(0.0389)	(0.0507)	(0.126)	(0.0738)	(0.0374)	(0.0617)	(0.0444)
Connection × Access × Female		0.0579			-0.140			0.0367	
		(0.110)			(0.167)			(0.0479)	
Connection × Access × Education (high)			-0.0826			0.0505			-0.0490
			(0.0685)			(0.109)			(0.0366)
Observations	4,422	4,422	4,422	4,422	4,422	4,422	4,422	4,422	4,422
R^2	0.187	0.192	0.192	0.249	0.252	0.251	0.129	0.130	0.130
Town FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×

Notes: Payment type from DHS (0/1). Sample and controls as in Table 3 (Columns 4 through 6). 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.15: Early internet availability and employment relationship

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Self			Family			Someone else	
Connection × Access	0.0674	-0.105	0.111**	-0.0495	-0.0518	-0.0485	0.0628	-0.124***	0.0498
	(0.0472)	(0.0742)	(0.0507)	(0.0348)	(0.0415)	(0.0396)	(0.0392)	(0.0439)	(0.0464)
Connection × Access × Female		0.226***			0.00201			0.256***	
		(0.0774)			(0.0454)			(0.0646)	
Connection × Access × Education (high)			-0.169***			-0.00153			0.0506
			(0.0525)			(0.0355)			(0.0529)
Observations	4,422	4,422	4,422	4,422	4,422	4,422	4,422	4,422	4,422
R^2	0.383	0.386	0.385	0.093	0.094	0.093	0.089	0.105	0.089
Town FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×

Notes: Employment relationship from DHS (0/1). Sample and controls as in Table 3 (Columns 4 through 6). 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.16: Employment effects by industrial composition (tradable)

	(1) Employed	(2) Agriculture	(3) Manufacturing	(4) Services
Connection × Access	0.146***	0.0962**	0.00708	0.0425
	(0.0288)	(0.0360)	(0.0232)	(0.0474)
Connection × Access × Tradable	0.0435*	-0.119***	0.0359	0.127***
	(0.0251)	(0.0383)	(0.0226)	(0.0389)
Observations	4,408	4,408	4,408	4,408
R^2	0.287	0.246	0.143	0.160
Town FE	×	×	×	×
Country × Year FE	×	×	×	×

Notes: Employment and occupation from DHS (0/1). Sample and controls as in Table 3 (Columns 4 through 6). 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.17: Employment effects by industrial composition (non-tradable)

	(1) Employed	(2) Agriculture	(3) Manufacturing	(4) Services
Connection × Access	0.0691*	0.0438	0.0505*	-0.0252
	(0.0357)	(0.0598)	(0.0263)	(0.0557)
Connection × Access × Non-tradable	-0.122**	0.0356	0.0319	-0.190***
	(0.0529)	(0.0615)	(0.0400)	(0.0637)
Observations	4,408	4,408	4,408	4,408
R^2	0.287	0.246	0.143	0.159
Town FE	×	×	×	×
Country × Year FE	×	×	×	×

Notes: Employment and occupation from DHS (0/1). Sample and controls as in Table 3 (Columns 4 through 6). 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.18: Migration: Robustness to NTL restriction

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Moved recently			Moved since longer			Non-mover		
Connection × Access	-0.0297	0.000231	-0.0431*	0.132**	0.160**	0.147***	-0.109	-0.0433	-0.109
	(0.0256)	(0.0785)	(0.0231)	(0.0514)	(0.0729)	(0.0542)	(0.0682)	(0.120)	(0.0667)
Connection × Access × Female		-0.0383			-0.0320			-0.0765	
		(0.0806)			(0.0710)			(0.0897)	
Connection × Access × Education (high)			0.0430			-0.0161			-0.0387
			(0.0661)			(0.0799)			(0.106)
Observations	4,918	4,918	4,918	5,051	5,051	5,051	4,918	4,918	4,918
#Countries	4	4	4	4	4	4	4	4	4
#Towns	45	45	45	45	45	45	45	45	45
Share treated	0.373	0.373	0.373	0.384	0.384	0.384	0.373	0.373	0.373
R^2	0.119	0.119	0.119	0.174	0.175	0.176	0.127	0.128	0.129
Town FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×
Lifted NTL restriction	×	×	×	×	×	×	×	×	×

Notes: Migration variables from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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.19: Migration: Robustness to town fixed effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Moved recently			Moved since longer			Non-mover		
Connection × Access	-0.0555*	0.00273	-0.105***	0.208***	0.266***	0.225***	-0.162*	-0.135	-0.134*
	(0.0310)	(0.0900)	(0.0263)	(0.0657)	(0.0853)	(0.0645)	(0.0834)	(0.156)	(0.0767)
Connection × Access × Female		-0.0788			-0.0658			-0.0257	
		(0.0896)			(0.0750)			(0.104)	
Connection × Access × Education (high)			0.150**			-0.0164			-0.125
			(0.0665)			(0.0763)			(0.0994)
Observations	4,250	4,250	4,250	4,423	4,423	4,423	4,250	4,250	4,250
#Countries	4	4	4	4	4	4	4	4	4
#Towns	39	39	39	39	39	39	39	39	39
Share treated	0.44	0.44	0.44	0.454	0.454	0.454	0.440	0.440	0.440
R^2	0.116	0.117	0.117	0.165	0.167	0.167	0.126	0.128	0.127
Region FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×

Notes: Migration variables from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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.20: Early internet availability and education

Education (high)	(1)	(2)	(3)	(4)	(5)	(6)
Connection × Access	-0.0445	-0.0209	-0.0450	-0.0544	-0.0491*	-0.0222
	(0.0308)	(0.0650)	(0.0308)	(0.0632)	(0.0258)	(0.0559)
Connection × Access × Female		-0.0309		0.0109		-0.0342
		(0.0699)		(0.0665)		(0.0611)
Observations	3,979	3,979	4,423	4,423	5,051	5,051
#Countries	4	4	4	4	4	4
#Towns	30	30	39	39	45	45
Share treated	0.417	0.417	0.454	0.454	0.417	0.417
R^2	0.289	0.289	0.285	0.286	0.283	0.283
Town FE	×	×			×	×
Region FE			×	×		
Country × Year FE	×	×	×	×	×	×
Lifted NTL restriction					×	×

Notes: At least secondary education from DHS (0/1). Controls as in Table 3 minus educational 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.21: Early internet availability and education by migration group

	(1)	(2)	(3)	(4)	(5)	(6)
	Moved recently		Moved since longer		Non-mover	
Connection × Access	0.0340	0.238*	-0.157***	-0.146	-0.0354	-0.0293
	(0.0721)	(0.137)	(0.0505)	(0.116)	(0.0467)	(0.0937)
Connection × Access × Female		-0.254		-0.0153		-0.00190
		(0.155)		(0.131)		(0.108)
Observations	753	753	1,272	1,272	1,843	1,843
#Countries	4	4	4	4	4	4
#Towns	28	28	30	30	30	30
Share treated	0.448	0.448	0.390	0.390	0.394	0.394
R^2	0.286	0.294	0.354	0.354	0.333	0.333
Town FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×

Notes: At least secondary education from (0/1). Controls as in Table 3 minus educational 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.22: The effect of early internet availability on employment by migration group

Employment	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Moved recently			Moved since longer			Non-mover		
Connection × Access	0.184***	0.188	0.0478	-0.0219	-0.0887	-0.0143	0.106*	0.246*	0.112*
	(0.0578)	(0.133)	(0.0746)	(0.0729)	(0.119)	(0.0910)	(0.0524)	(0.129)	(0.0577)
Connection × Access × Female		-0.0163			0.0815			-0.183	
		(0.163)			(0.108)			(0.123)	
Connection × Access × Education (high)			0.313***			-0.0301			-0.0648
			(0.107)			(0.137)			(0.147)
Observations	753	753	753	1,272	1,272	1,272	1,843	1,843	1,843
#Countries	4	4	4	4	4	4	4	4	4
#Towns	28	28	28	30	30	30	30	30	30
Share treated	0.448	0.448	0.448	0.390	0.390	0.390	0.394	0.394	0.394
R^2	0.326	0.327	0.333	0.275	0.278	0.275	0.304	0.314	0.304
Town FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×

Notes: Employment and migration from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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.23: The effect of early internet availability on employment (without Ethiopia)

Employment	(1)	(2)	(3)
Connection × Access	0.0890**	0.00513	0.0732*
	(0.0345)	(0.0637)	(0.0408)
Connection × Access × Female		0.0960*	
		(0.0540)	
Connection × Access × Education (high)			0.0326
			(0.0874)
Observations	3,979	3,979	3,979
#Countries	4	4	4
#Towns	30	30	30
Share treated	0.417	0.417	0.417
R^2	0.291	0.298	0.292
Town FE	×	×	×
Country × Year FE	×	×	×

Notes: Employment from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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.24: Early internet availability and employment by migration group (agriculture)

Agriculture	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Moved recently			Moved since longer			Non-mover	
Connection × Access	0.212***	0.197**	0.182***	0.00336	-0.322**	0.0534	0.172**	0.180	0.219***
	(0.0462)	(0.0897)	(0.0631)	(0.0644)	(0.131)	(0.0704)	(0.0639)	(0.161)	(0.0649)
Connection × Access × Female		0.00801			0.396***			-0.0263	
		(0.0992)			(0.127)			(0.142)	
Connection × Access × Education (high)			0.0346			-0.171**			-0.272***
			(0.100)			(0.0746)			(0.0703)
Observations	753	753	753	1,272	1,272	1,272	1,843	1,843	1,843
#Countries	4	4	4	4	4	4	4	4	4
#Towns	28	28	28	30	30	30	30	30	30
Share treated	0.448	0.448	0.448	0.390	0.390	0.390	0.394	0.394	0.394
R^2	0.178	0.181	0.182	0.213	0.229	0.217	0.318	0.322	0.329
Town FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×

Notes: Occupation from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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.25: Early internet availability and employment by migration group (manufacturing)

Manufactoring	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Moved recently			Moved since longer			Non-mover		
Connection × Access	-0.113***	-0.219*	-0.127***	-0.0619	0.0206	-0.0268	-0.0336	-0.388***	-0.0243
	(0.0303)	(0.107)	(0.0398)	(0.0475)	(0.207)	(0.0496)	(0.0382)	(0.112)	(0.0423)
Connection × Access × Female		0.131			-0.103			0.375***	
		(0.109)			(0.215)			(0.114)	
Connection × Access × Education (high)			0.0734			-0.111			-0.0545
			(0.0798)			(0.0813)			(0.0535)
Observations	753	753	753	1,272	1,272	1,272	1,843	1,843	1,843
#Countries	4	4	4	4	4	4	4	4	4
#Towns	28	28	28	30	30	30	30	30	30
Share treated	0.448	0.448	0.448	0.390	0.390	0.390	0.394	0.394	0.394
R^2	0.201	0.213	0.204	0.157	0.161	0.159	0.131	0.145	0.132
Town FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×

Notes: Occupation from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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.26: Early internet availability and employment by migration group (services)

Services	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Moved recently			Moved since longer			Non-mover		
Connection × Access	0.0847*	0.211	-0.00678	0.0366	0.213	-0.0409	-0.0323	0.454***	-0.0832
	(0.0461)	(0.162)	(0.0685)	(0.0821)	(0.132)	(0.0984)	(0.0695)	(0.134)	(0.0746)
Connection × Access × Female		-0.155			-0.212			-0.531***	
		(0.204)			(0.141)			(0.132)	
Connection × Access × Education (high)			0.205*			0.251*			0.261*
			(0.111)			(0.123)			(0.135)
Observations	753	753	753	1,272	1,272	1,272	1,843	1,843	1,843
#Countries	4	4	4	4	4	4	4	4	4
#Towns	28	28	28	30	30	30	30	30	30
Share treated	0.448	0.448	0.448	0.390	0.390	0.390	0.394	0.394	0.394
R^2	0.188	0.193	0.193	0.181	0.185	0.183	0.158	0.164	0.167
Town FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×

Notes: Occupation from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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.27: Early internet availability and employment by sector (without Ethiopia)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Agriculture			Manufacturing			Services		
Connection × Access	0.116*	0.0421	0.141**	-0.0644**	-0.124*	-0.0698**	0.0370	0.0868	0.00220
	(0.0583)	(0.0983)	(0.0579)	(0.0280)	(0.0695)	(0.0327)	(0.0666)	(0.100)	(0.0793)
Connection × Access × Female		0.0898			0.0705			-0.0644	
		(0.0835)			(0.0724)			(0.0864)	
Connection × Access × Education (high)			-0.130***			0.0282			0.135
			(0.0469)			(0.0494)			(0.0913)
Observations	3,979	3,979	3,979	3,979	3,979	3,979	3,979	3,979	3,979
#Countries	4	4	4	4	4	4	4	4	4
#Towns	30	30	30	30	30	30	30	30	30
Share treated	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417	0.417
R^2	0.247	0.253	0.254	0.141	0.144	0.142	0.153	0.153	0.155
Town FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×

Notes: Occupation from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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.28: Banking and digital devices

	(1) Bank	(2) Mobile phone	(3) Computer	(4) Internet
Internet availability	0.122**	0.176***	0.0476*	0.160***
	(0.0518)	(0.0661)	(0.0265)	(0.0444)
Observations	4,770	5,734	3,115	3,120
#Countries	4	4	2	2
#Towns	52	64	38	38
Share treated	0.375	0.468	0.610	0.609
R^2	0.275	0.245	0.147	0.154
State FE	×	×	×	×

Notes: Variables from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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.29: Banking and digital devices by gender

	(1) Bank	(2) Mobile phone	(3) Computer	(4) Internet
Internet availability	0.102*	0.153**	0.0531	0.158***
	(0.0553)	(0.0700)	(0.0329)	(0.0423)
Internet availability × Female	0.0309	0.0337	-0.00881	0.00294
	(0.0222)	(0.0269)	(0.0249)	(0.0153)
Observations	4,770	5,734	3,115	3,120
R^2	0.276	0.245	0.147	0.154
State FE	×	×	×	×

Notes: Variables from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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.30: Banking and digital devices by education

	(1) Bank	(2) Mobile phone	(3) Computer	(4) Internet
Internet availability	0.128**	0.222***	0.0373	0.150***
	(0.0502)	(0.0801)	(0.0279)	(0.0455)
Internet availability × Education (high)	-0.00945	-0.0745*	0.0136	0.0132
	(0.0374)	(0.0421)	(0.0232)	(0.0216)
Observations	4,770	5,734	3,115	3,120
R^2	0.275	0.246	0.147	0.154
State FE	×	×	×	×

Notes: Variables from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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.31: Access points and employment: Robustness

Employment	(1)	(2)	(3)	(4)	(5)	(6)
Connection × Access	0.0306	-0.0722**	0.0283	0.0520*	-0.0130	0.0474
	(0.0265)	(0.0274)	(0.0348)	(0.0282)	(0.0391)	(0.0385)
Connection × Access × Female		0.134***			0.0774	
		(0.0389)			(0.0513)	
Connection × Access × Education (high)			-0.0176			-0.00507
			(0.0504)			(0.0610)
Observations	11,987	11,987	11,987	11,987	11,987	11,987
R^2	0.075	0.119	0.081	0.236	0.240	0.237
Town FE	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×
GSM coverage				×	×	×
Market access				×	×	×
Geographic controls				×	×	×
Individual controls				×	×	×

Notes: The table reports amenities by their frequency in OSM in Africa in 2013. Only amenities with more than 250 entries are shown.

Table D.32: Cybercafés and employment: Robustness

Employment	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Connection × Access	0.0528**	0.0369	0.0370	0.0419	0.0135	0.0479	0.0527**	0.0350	0.0503*
	(0.0266)	(0.0251)	(0.0391)	(0.0684)	(0.0748)	(0.0688)	(0.0221)	(0.0390)	(0.0287)
Connection × Access × Female		0.0221			0.0350			0.0222	
		(0.0403)			(0.0416)			(0.0455)	
Connection × Access × Education (high)			0.0460			-0.0331			0.00203
			(0.0449)			(0.0426)			(0.0466)
Observations	30,959	30,959	30,959	4,078	4,078	4,078	15,366	15,366	15,366
#Countries	4	4	4	2	2	2	4	4	4
#Towns	139	139	139	30	30	30	150	150	150
Share treated	0.179	0.179	0.179	0.182	0.182	0.182	0.365	0.365	0.365
R^2	0.233	0.233	0.233	0.192	0.195	0.193	0.243	0.244	0.243
Town FE	×	×	×	×	×	×			
Region FE							×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×
No timing restriction	×	×	×						
No nodal restriction				×	×	×			

Notes: Employment from DHS (0/1). Controls as in Table 3 (Columns 4 through 6). 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.33: Cybercafés and employment by sector

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Agriculture			Manufacturing			Services	
Connection × Access	0.111***	0.0896	0.117***	-0.0187	-0.0221	-0.0302*	-0.0479*	-0.0703	-0.0442
	(0.0215)	(0.0567)	(0.0260)	(0.0163)	(0.0293)	(0.0156)	(0.0234)	(0.0439)	(0.0284)
Connection × Access × Female		0.0277			0.00246			0.0298	
		(0.0782)			(0.0348)			(0.0508)	
Connection × Access × Education (high)			-0.0309			0.0326			-0.00577
			(0.0317)			(0.0319)			(0.0362)
Observations	11,987	11,987	11,987	11,987	11,987	11,987	11,987	11,987	11,987
R^2	0.253	0.253	0.254	0.118	0.118	0.118	0.130	0.130	0.130
Town FE	×	×	×	×	×	×	×	×	×
Country × Year FE	×	×	×	×	×	×	×	×	×

Notes: Occupation from DHS (0/1). Sample and controls as in Table 6. 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.34: List of top amenities in OSM

Amenity	Count
place of worship	14141
fuel	13481
restaurant	13079
school	11819
parking	10263
hospital	5861
pharmacy	4817
bank	4762
cafe	4669
toilets	3444
fast food	3409
bar	2987
public building	2839
drinking water	2578
bench	2318
police	2122
atm	2046
post office	1969
telephone	1843
pub	1756
recycling	1667
fountain	1215
townhall	1140
grave yard	1075
bus station	1068
kindergarten	1061
taxi	1058
post box	1034
waste basket	752
doctors	684
marketplace	592
car rental	591
embassy	572
library	564
university	553
cinema	501
swimming pool	484
car wash	474
fire station	459
college	442
shelter	422
theatre	413
bicycle rental	403
ferry terminal	372
nightclub	292
community centre	288
bureau de change	277

Notes: 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.35: Amenities and employment

Employment	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A	Cybercafé	Cafe	Bar	Restaurant	Fast food	Pub	Nightclub	Worship
Connection × Amenity	0.0444*	-0.0197	0.0415	0.0691***	-0.00632	-0.0177	-0.00365	0.000550
	(0.0240)	(0.0301)	(0.0453)	(0.0194)	(0.0271)	(0.0450)	(0.0482)	(0.0370)
Observations	11,987	14,117	8,846	19,271	9,894	7,083	7,682	20,655
#Countries	4	4	4	4	4	4	4	4
#Towns	63	63	62	78	57	57	56	81
Share treated	0.462	0.548	0.268	0.702	0.337	0.085	0.146	0.742
R^2	0.236	0.237	0.245	0.236	0.232	0.237	0.238	0.233
Panel B	School	College	University	Library	Kinder-garten	Theatre	Cinema	Telephone
Connection × Amenity	0.0506*	0.0785	0.0223	0.0565	0.00518	-0.0639*	0.0265	0.0768
	(0.0287)	(0.0483)	(0.0277)	(0.0440)	(0.0384)	(0.0327)	(0.0356)	(0.0478)
Observations	16,953	8,813	17,558	8,086	7,711	7,127	9,059	7,746
#Countries	4	4	4	4	4	4	4	4
#Towns	73	59	68	56	56	54	57	56
Share treated	0.709	0.371	0.690	0.188	0.149	0.079	0.276	0.307
R^2	0.235	0.240	0.235	0.243	0.230	0.238	0.233	0.243
Panel C	Hospital	Doctors	Pharmacy	Bank	ATM	Townhall	Community centre	Public building
Connection × Amenity	-0.0110	-0.00182	-0.0554	0.00744	-0.0532**	-0.0439	-0.0557	0.0595**
	(0.0285)	(0.0442)	(0.0374)	(0.0303)	(0.0214)	(0.0315)	(0.0442)	(0.0284)
Observations	17,524	8,265	8,357	17,817	12,288	8,124	7,759	11,736
#Countries	4	4	4	4	4	4	4	4
#Towns	77	57	59	73	58	59	55	61
Share treated	0.756	0.330	0.215	0.709	0.480	0.192	0.154	0.528
R^2	0.236	0.242	0.235	0.234	0.230	0.239	0.236	0.237
Panel D	Bus station	Taxi	Fuel	Parking	Ferry terminal	Swimming pool	Toilets	Waste basket
Connection × Amenity	0.0428	0.00168	-0.0235	0.0232	0.130*	-0.123***	0.0234	-0.0433
	(0.0269)	(0.0360)	(0.0304)	(0.0468)	(0.0702)	(0.0395)	(0.0318)	(0.0567)
Observations	15,914	7,112	23,207	9,493	6,752	9,321	8,540	7,195
#Countries	4	4	4	4	4	4	4	4
#Towns	77	56	93	57	54	55	54	54
Share treated	0.601	0.245	0.762	0.351	0.184	0.296	0.351	0.088
R^2	0.237	0.245	0.236	0.234	0.239	0.240	0.234	0.235
Panel E	Bureau de change	Market-place	Post office	Post box	Police	Fire station	Embassy	
Connection × Amenity	-0.0106	0.0385*	0.0577**	-0.0172	0.0368	-0.0639*	0.0182	
	(0.0477)	(0.0203)	(0.0244)	(0.0583)	(0.0280)	(0.0327)	(0.0538)	
Observations	7,844	14,454	12,798	7,043	14,107	7,127	6,617	
#Countries	4	4	4	4	4	4	4	
#Towns	58	62	64	56	69	54	54	
Share treated	0.163	0.656	0.629	0.081	0.613	0.079	0.163	
R^2	0.244	0.237	0.236	0.242	0.233	0.238	0.238	
Town FE	×	×	×	×	×	×	×	
Country × Year FE	×	×	×	×	×	×	×	

Notes: Employment from DHS (0/1). Historic amenities from 2013 from OpenStreetMap (2025). Each column uses a different type of amenity as time-invariant treatment dummy. Controls as in Table 3 (Columns 4 through 6). 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.36: Shops and employment

Employment	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A	Cybercafé	Supermarket	Convenience	Clothes	Kiosk	Bakery	Hairdresser	Car repair
Connection × Shop	0.0444*	0.0139	-0.0968***	-0.0369	-0.0589	-0.0727***	-0.00274	0.0257
	(0.0240)	(0.0335)	(0.0217)	(0.0467)	(0.0470)	(0.0255)	(0.0325)	(0.0247)
Observations	11,987	11,831	11,741	7,353	7,195	7,759	9,736	8,442
R-squared	0.236	0.233	0.235	0.237	0.236	0.236	0.231	0.238
#Countries	4	4	4	4	4	4	4	4
#Towns	63	67	59	55	54	55	56	56
Share treated	.462	.468	.441	.107	.1	.177	.326	.223
Panel B	Car	Furniture	Electronics	Books	Jewelry	Greengrocer	Shoes	Hardware
Connection × Shop	0.0527	0.0459	-0.00381	0.0403	-0.0514*	0.769***	0.0527	-0.0639*
	(0.0309)	(0.0491)	(0.0271)	(0.0316)	(0.0294)	(0.0561)	(0.0366)	(0.0327)
Observations	10,131	7,364	8,528	7,436	7,285	6,977	7,794	7,127
R-squared	0.235	0.232	0.233	0.235	0.239	0.239	0.229	0.238
#Countries	4	4	4	4	4	4	4	4
#Towns	57	55	57	55	55	54	56	54
Share treated	.352	.109	.23	.255	.099	.059	.158	.079
Panel C	Travel agency	Computer	Beverages	Mall	Mobile phone	Toys	Dry cleaning	Stationery
Connection × Shop	0.0485	-0.0557	-0.0557	0.0142	-0.0589	0.0142	-0.0433	0.153***
	(0.0593)	(0.0442)	(0.0442)	(0.0478)	(0.0470)	(0.0478)	(0.0567)	(0.0377)
Observations	6,563	7,759	7,759	8,540	7,195	8,540	7,195	7,450
R-squared	0.237	0.236	0.236	0.234	0.236	0.234	0.235	0.241
#Countries	4	4	4	4	4	4	4	4
#Towns	53	55	55	54	54	54	54	55
Share treated	.156	.154	.154	.231	.1	.231	.088	.119
Panel D	Optician	Chemist	Variety store	Department store	Boutique			
Connection × Shop	-0.0433	0.0482	-0.0433	-0.0639*	0.0168			
	(0.0567)	(0.0578)	(0.0567)	(0.0327)	(0.0557)			
Observations	7,195	7,278	7,195	7,127	7,759			
R-squared	0.235	0.233	0.235	0.238	0.236			
#Countries	4	4	4	4	4			
#Towns	54	54	54	54	55			
Share treated	.088	.098	.088	.079	.286			
Town FE	×	×	×	×	×			
Country × Year FE	×	×	×	×	×			

Notes: Employment from DHS (0/1). Historic shops from 2013 from OpenStreetMap (2025). Each column uses a different type of shop as time-invariant treatment dummy. Controls as in Table 3 (Columns 4 through 6). 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.37: Model specification: Robustness to the specification of the control group

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Connection × Access	0.104***	0.0964**	0.0865**	0.0894*	0.0807*	0.112*	0.0981**
	(0.0374)	(0.0413)	(0.0437)	(0.0452)	(0.0451)	(0.0609)	(0.0403)
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 post-observation period years. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Controls as in Column (3) of 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.38: Omitted variables: Robustness to lagged mobile coverage

NTL intensity	(1)	(2)	(3)	(4)	(5)	(6)
Connection × Access	0.104***	0.104***	0.0994***	0.100***	0.0987***	0.0953**
	(0.0374)	(0.0372)	(0.0377)	(0.0365)	(0.0364)	(0.0370)
Mobile coverage (GSM)	0.0511					
	(0.0408)					
GSM coverage (lag 1)		0.0690				
		(0.0436)				
GSM coverage (lag 2)			-0.0195			
			(0.0424)			
GSM coverage (lag 3)				0.0501		
				(0.0346)		
GSM coverage (lag 4)					0.0586*	
					(0.0331)	
GSM coverage (lag 5)						0.0596*
						(0.0332)
Market access	-0.0298	-0.0307	-0.0263	-0.0280	-0.0283	-0.0279
	(0.0958)	(0.0963)	(0.0961)	(0.0953)	(0.0953)	(0.0952)
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 log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Same towns and geographic controls as in Table 2 (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.39: Omitted variables: Robustness to different market access measures

NTL intensity	(1)	(2)	(3)	(4)
Connection × Access	0.104***	0.104***	0.103***	0.104***
	(0.0374)	(0.0375)	(0.0376)	(0.0374)
Mobile coverage (GSM)	0.0511	0.0511	0.0496	0.0532
	(0.0408)	(0.0408)	(0.0407)	(0.0408)
Market access (2000)	-0.0298			
	(0.0958)			
Market access (1990)		-0.0279		
		(0.0966)		
Market access (pop)			-0.0365	
			(0.0283)	
Market access (pop, zero)				-0.0372
				(0.0653)
Observations	2,024	2,024	2,024	2,024
R^2	0.939	0.939	0.939	0.939
Town FE	×	×	×	×
Country × Year FE	×	×	×	×

Notes: The table presents robustness checks with respect to different market access measures. NTL intensity is measured as the log sum of NTL intensities on the *Africapolis* built-up area with a 2-kilometer buffer. Same towns and geographic controls as in Table 2 (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.40: Omitted variables: Electricity I

Electricity	(1)	(2)	(3)	(4)	(5)	(6)
Connection × Access	0.0393	0.0440	0.0253	0.0237	-0.0206	-0.0241
	(0.0719)	(0.0696)	(0.0761)	(0.0697)	(0.0627)	(0.0588)
Observations	4,417	4,417	4,927	4,927	5,637	5,637
R^2	0.460	0.500	0.475	0.509	0.474	0.510
#Countries	5	5	5	5	5	5
#Towns	35	35	46	46	52	52
Share treated	0.394	0.394	0.428	0.428	0.359	0.359
Town FE	×	×			×	×
Country × Year FE	×	×	×	×	×	×
No light restriction	×	×	×	×	×	×
Individual controls		×		×		×
Region FE			×	×		

Notes: Electricity at the dwelling from DHS (0/1). Controls as in Table 2 (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. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

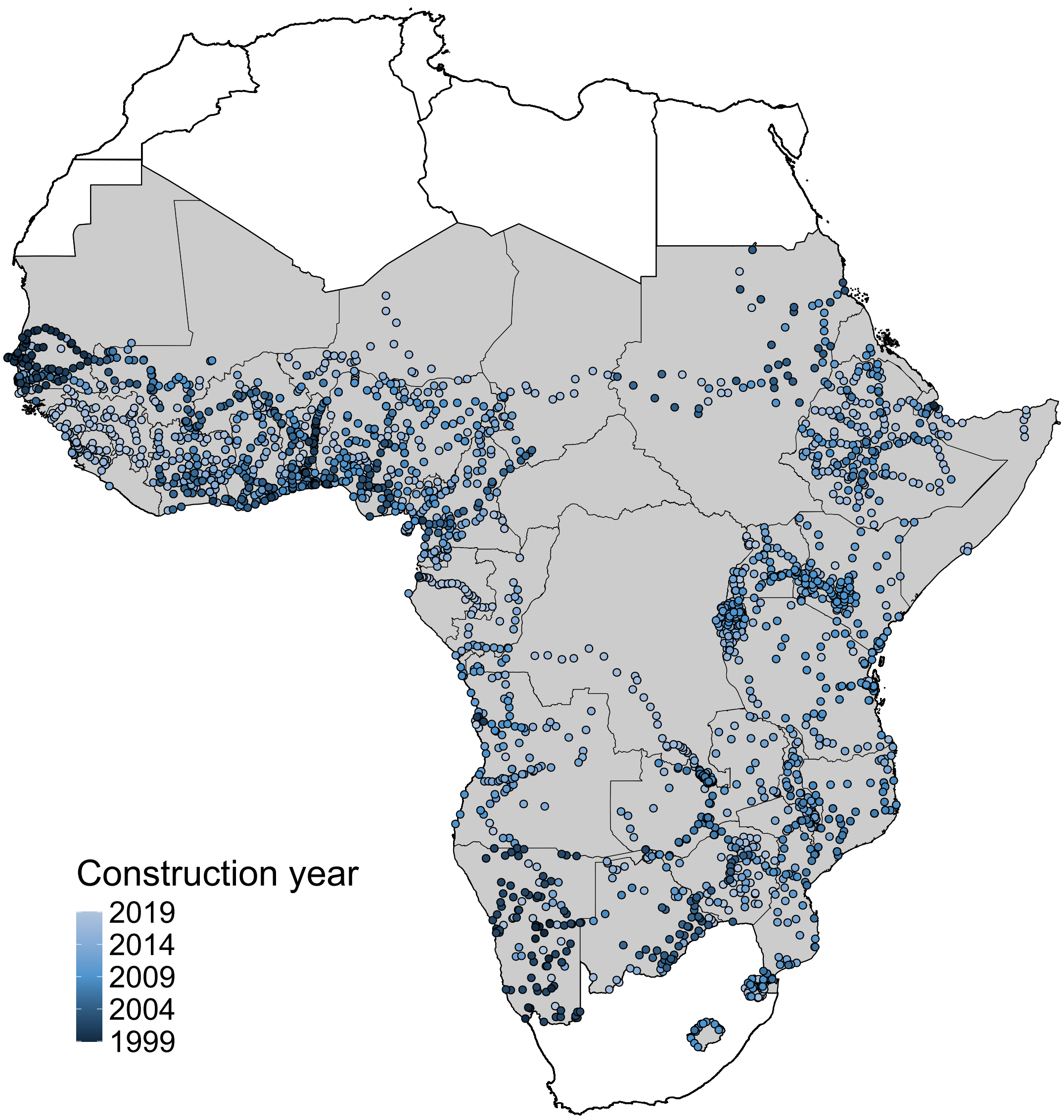
Table D.41: Omitted variables: Electricity II

Electricity	(1)	(2)	(3)	(4)	(5)	(6)
Connection × Access	0.0388	0.0421	0.0229	0.0222	-0.0149	-0.0196
	(0.0695)	(0.0702)	(0.0765)	(0.0708)	(0.0584)	(0.0556)
Connection × Electricity	-0.0400	-0.0435	-0.0398	-0.0279	-0.0673	-0.0528
	(0.0987)	(0.0840)	(0.107)	(0.0947)	(0.0756)	(0.0691)
Observations	4,417	4,417	4,927	4,927	5,637	5,637
R^2	0.460	0.500	0.475	0.509	0.475	0.510
#Countries	5	5	5	5	5	5
#Towns	35	35	46	46	52	52
Share treated	0.394	0.394	0.428	0.428	0.359	0.359
Town FE	×	×			×	×
Country × Year FE	×	×	×	×	×	×
No light restriction	×	×	×	×	×	×
Individual controls		×		×		×
Region FE			×	×		

Notes: Electricity at the dwelling from DHS (0/1). Controls as in Table 2 (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. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

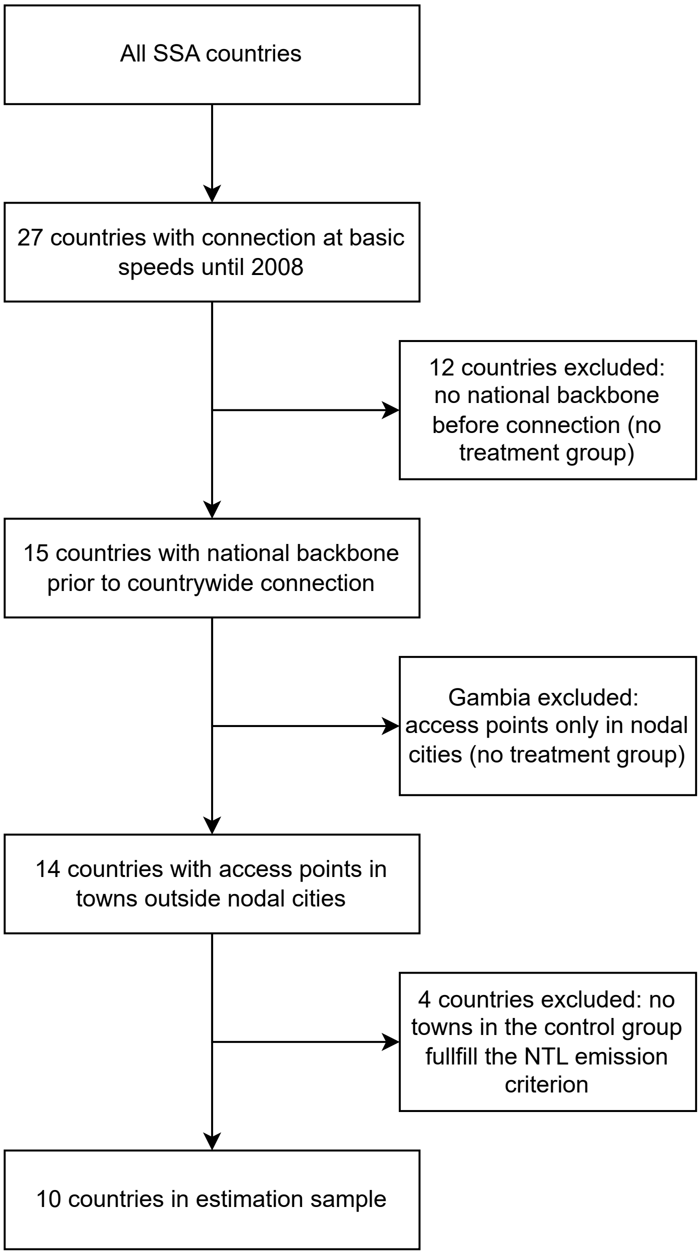
Appendix E. Figures

Figure E.1: Overview of all access points



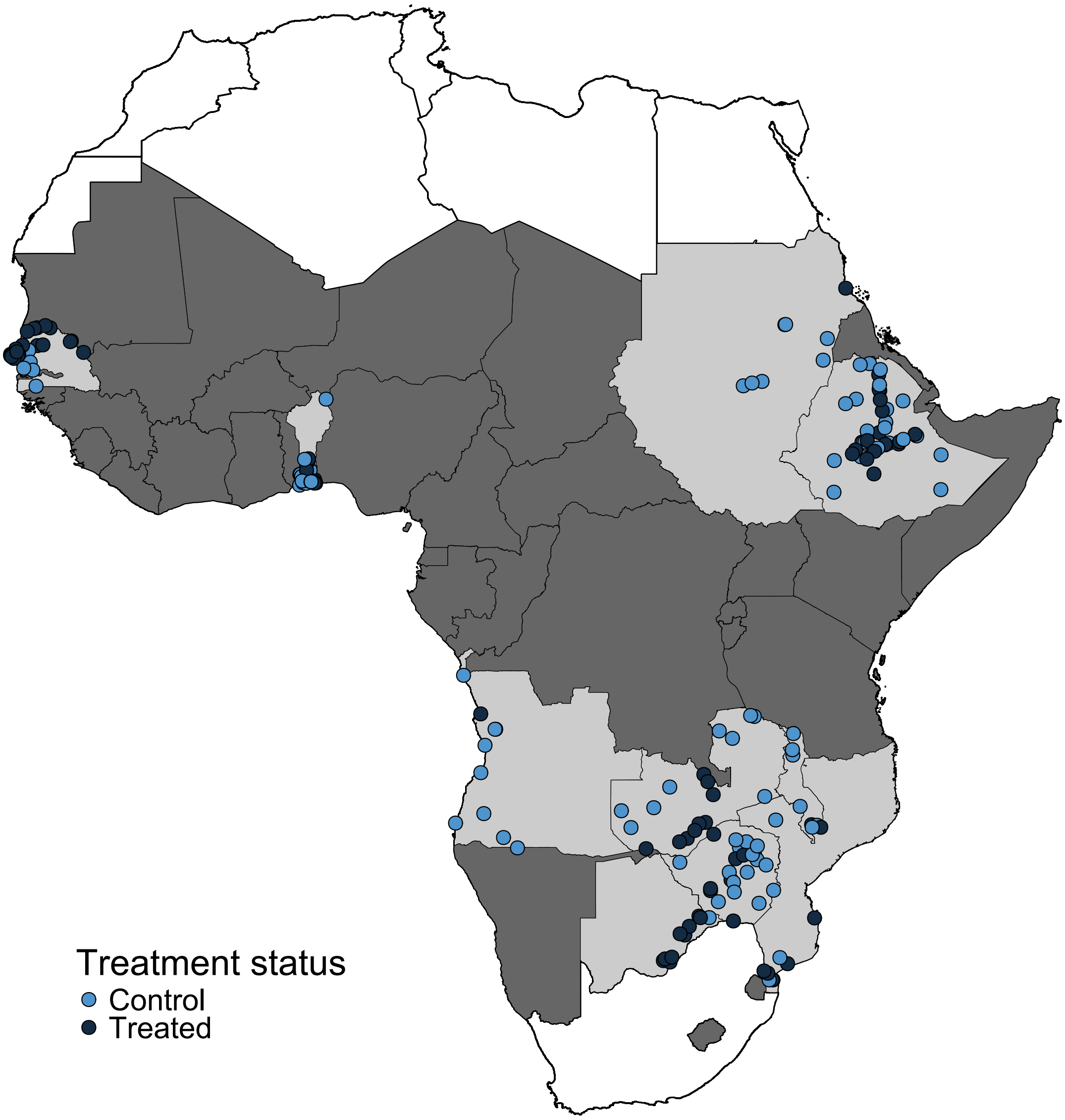
Notes: The figure maps the location of all SSA access points. Blue coloring indicates construction years, with brighter blue corresponding to later years.

Figure E.2: Flowchart of estimation sample



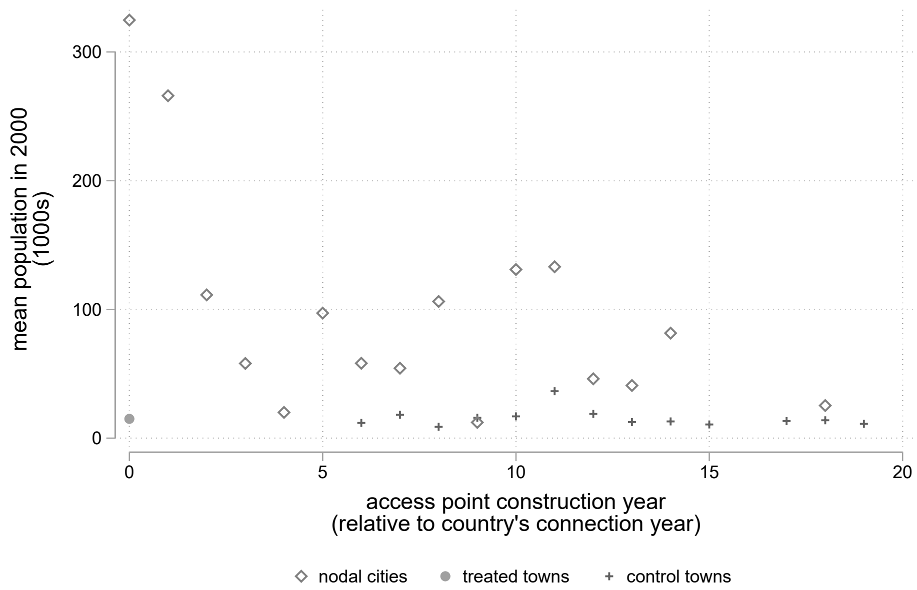
Notes: The figure depicts which countries remain in the estimation sample.

Figure E.3: Overview of the estimation sample

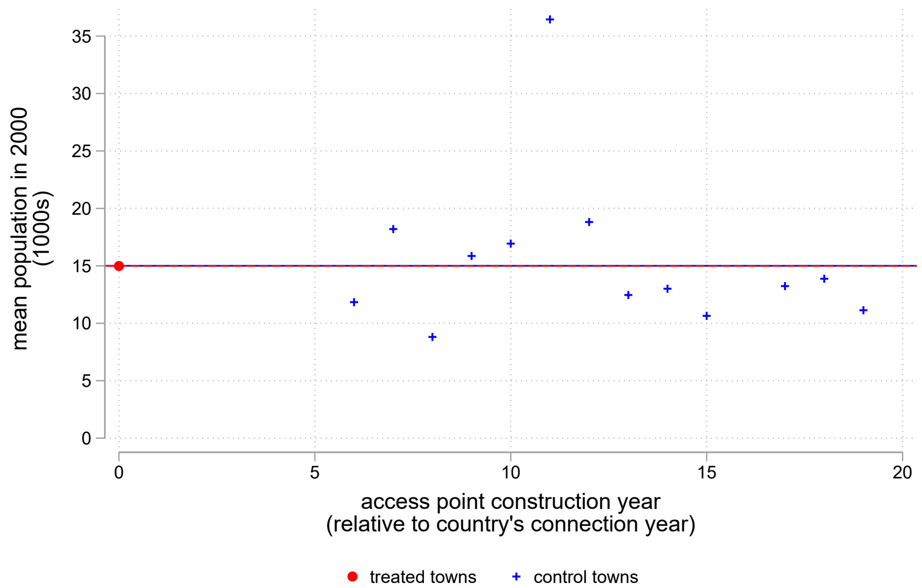


Notes: The figure maps the countries in our main sample (brighter gray) and the towns in the treatment and control group as dots.

Figure E.4: Population of cities and town with national backbone access over time



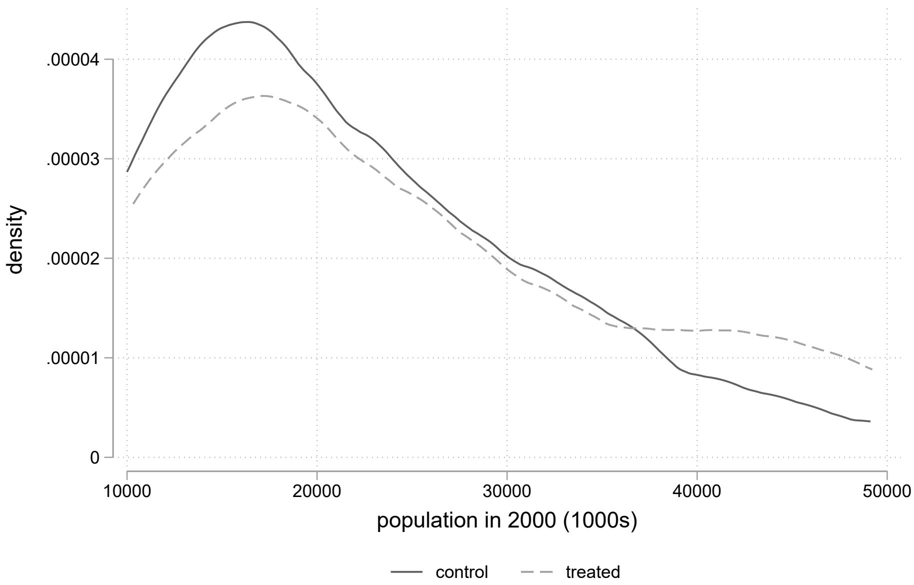
(a) with nodal cities



(b) treatment and control group towns

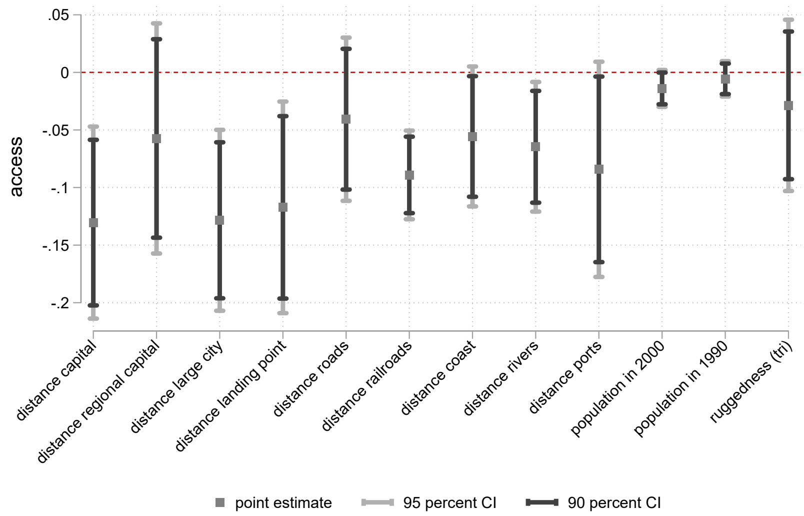
Notes: The figure depicts the average population size of cities and towns with national backbone access by year relative to the connection year. In Panel (a), the gray dot in the lower left corner represents the treated towns, while the control towns are represented by the plus symbol and the nodal cities 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.5: Population distribution

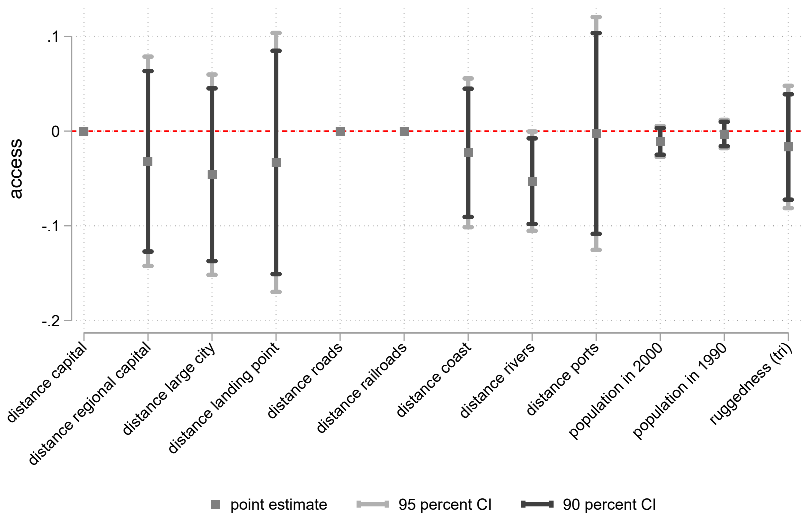


Notes: The figure plots kernel density estimates for the distribution of population size in 2000, separately for treated and control towns (restricted to a population minimum of 10,000 inhabitants).

Figure E.6: Timing of access to the national backbone and town characteristics



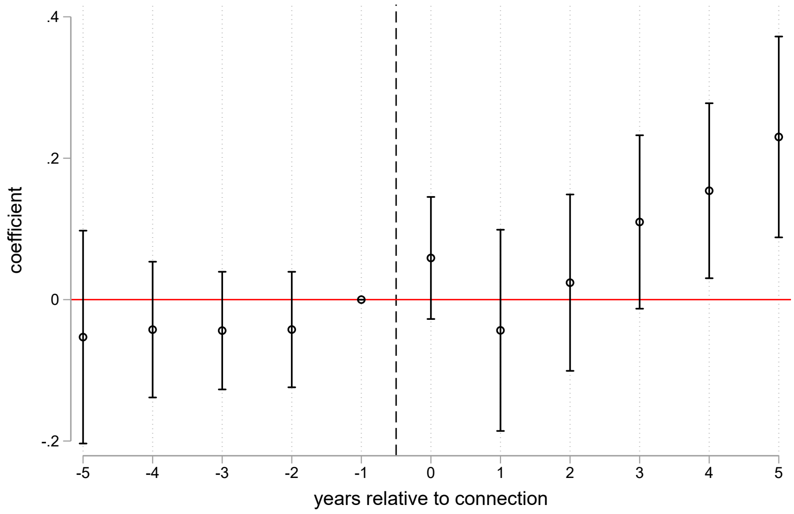
(a) base



(b) with controls

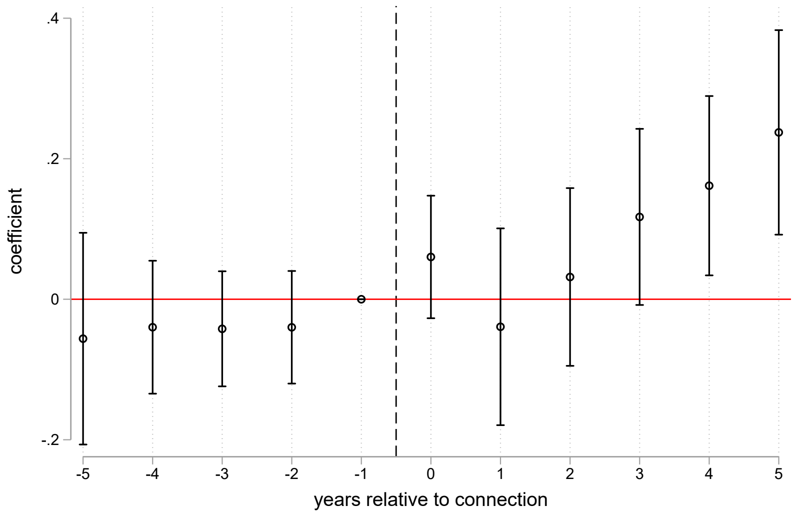
Notes: Panels (a) and (b) report OLS estimates from separate univariate regressions on standardized (mean zero, unitary standard deviation) town characteristics. Estimates in Panel (a) are conditional on country fixed effects. Estimates in Panel (b) additionally control for the basic geographic characteristics: the log distance to the capital city and indicators for local availability of and log 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% level using standard errors clustered at the access point level.

Figure E.7: Dynamic effects of early internet availability on local economic development I



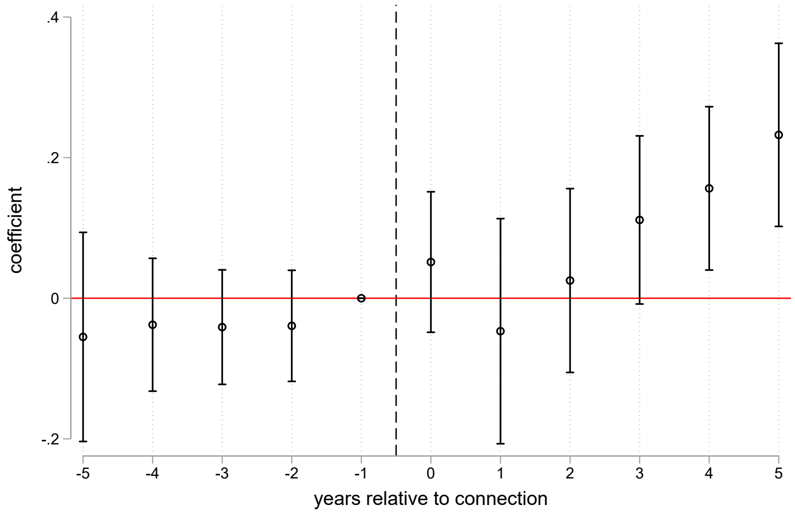
Notes: The figure presents the event study coefficients based on Equation 3 without any controls. The outcome is NTL intensity, measured as the log sum of NTL intensities, on the *Africapolis* built-up area with a 2-kilometer buffer. The event is defined as the year a country receives its first internet connection via an SMC (potentially through a neighboring country). Confidence intervals are drawn at the 95% level using standard errors clustered at the level of the closest access point.

Figure E.8: Dynamic effects of early internet availability on local economic development II



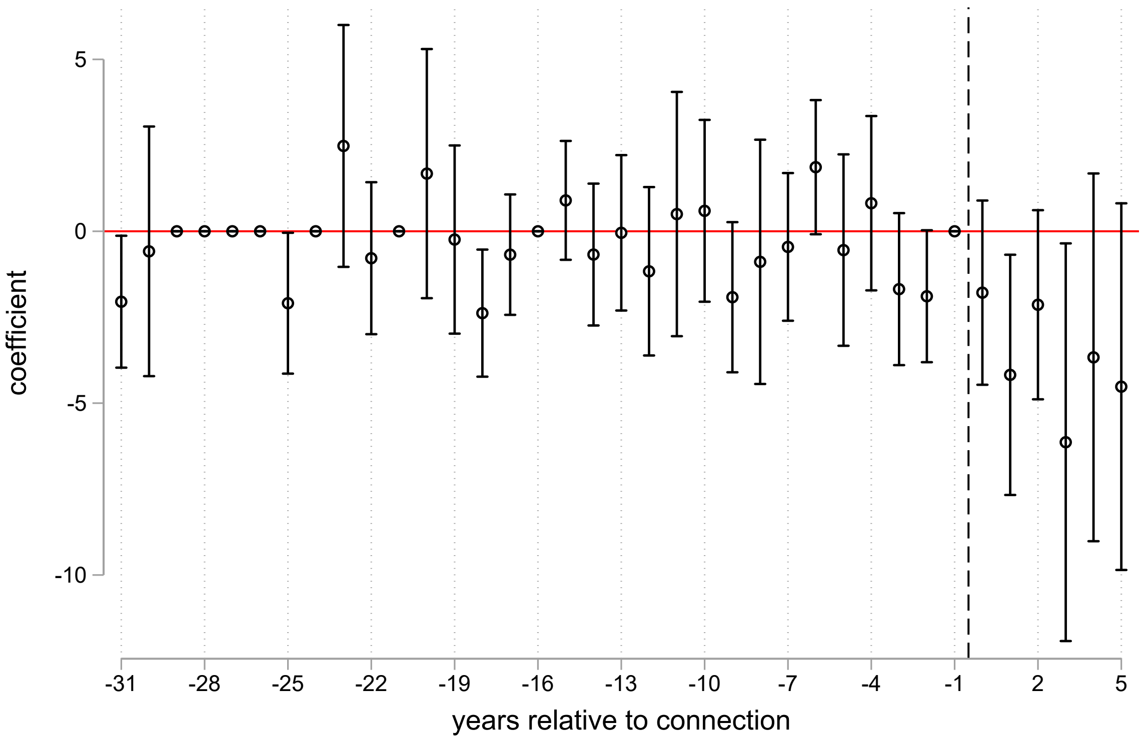
Notes: The figure presents the event study coefficients based on Equation 3 with GSM mobile coverage and market access as only controls. The outcome is NTL intensity, measured as the log sum of NTL intensities, on the *Africapolis* built-up area with a 2-kilometer buffer. The event is defined as the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

Figure E.9: Dynamic effects of early internet availability on local economic development III



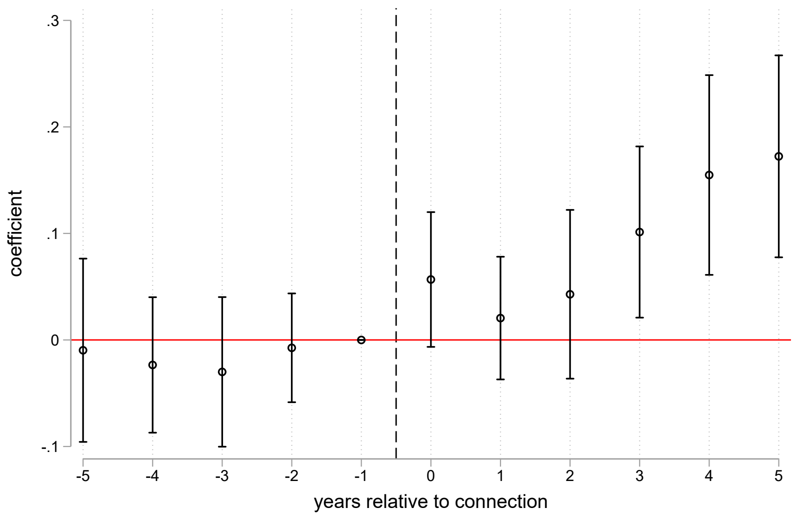
Notes: The figure presents the event study coefficients based on Equation 3 with GSM mobile coverage, market access, and all geographic controls. The outcome is NTL intensity, measured as the log sum of NTL intensities, on the *Africapolis* built-up area with a 2-kilometer buffer. The event is defined 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% level using standard errors clustered at the level of the closest access point.

Figure E.10: Dynamic effects on in-migration



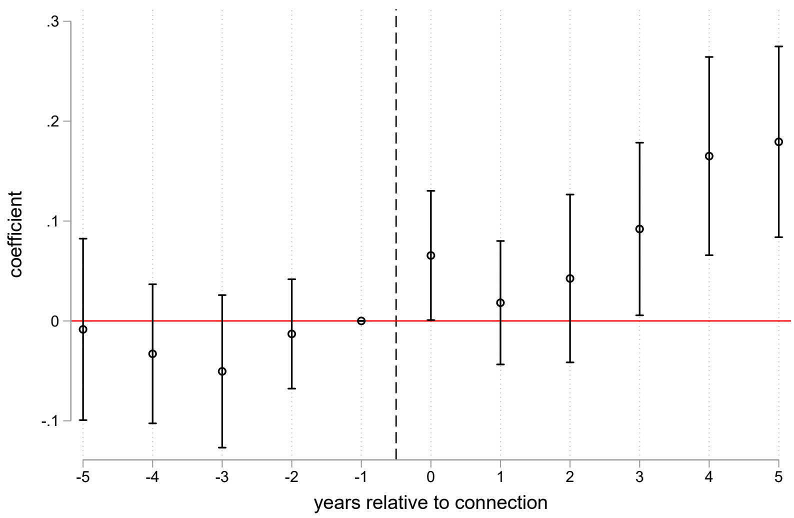
Note: The figure presents the event study coefficients for the migration analysis. The time reflects years of residence relative to the countrywide internet connection year. Confidence intervals are drawn at the 95% level using standard errors clustered at the level of the closest access point.

Figure E.11: Model specification: Staggered treatment (Sun and Abraham, 2021) I



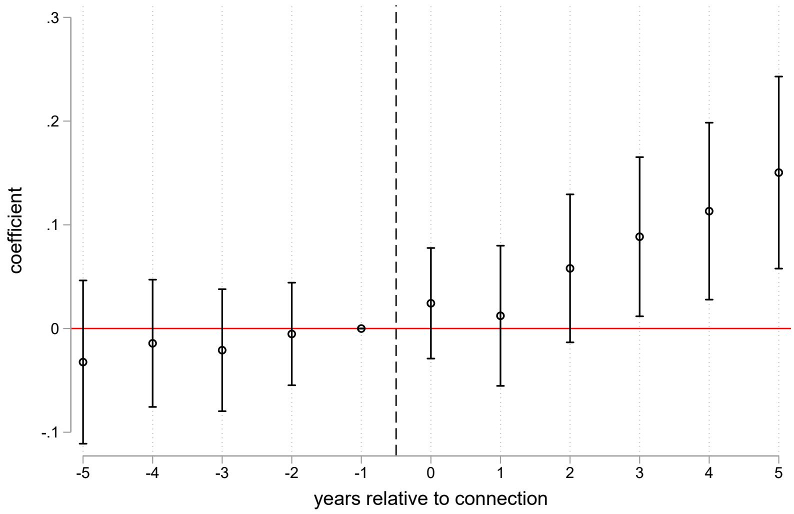
Notes: The figure presents the event study coefficients based on the estimator proposed by (Sun and Abraham, 2021) and corresponding to Table 8 (Column 3). The outcome is NTL intensity, measured as the log sum of NTL intensities, on the *Africapolis* built-up area with a 2-kilometer buffer. Confidence intervals are drawn at the 95% level using standard errors clustered at the level of the closest access point.

Figure E.12: Model specification: Staggered treatment (Sun and Abraham, 2021) II



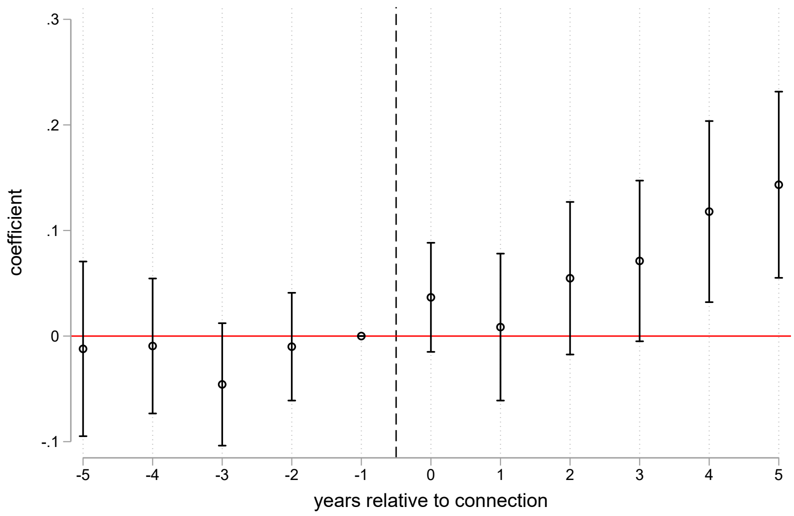
Notes: The figure presents the event study coefficients based on the estimator proposed by (Sun and Abraham, 2021) and corresponding to Table 8 (Column 6). The outcome is NTL intensity, measured as the log sum of NTL intensities, on the *Africapolis* built-up area with a 2-kilometer buffer. Confidence intervals are drawn at the 95% level using standard errors clustered at the level of the closest access point.

Figure E.13: Model specification: Staggered treatment (TWFE) I



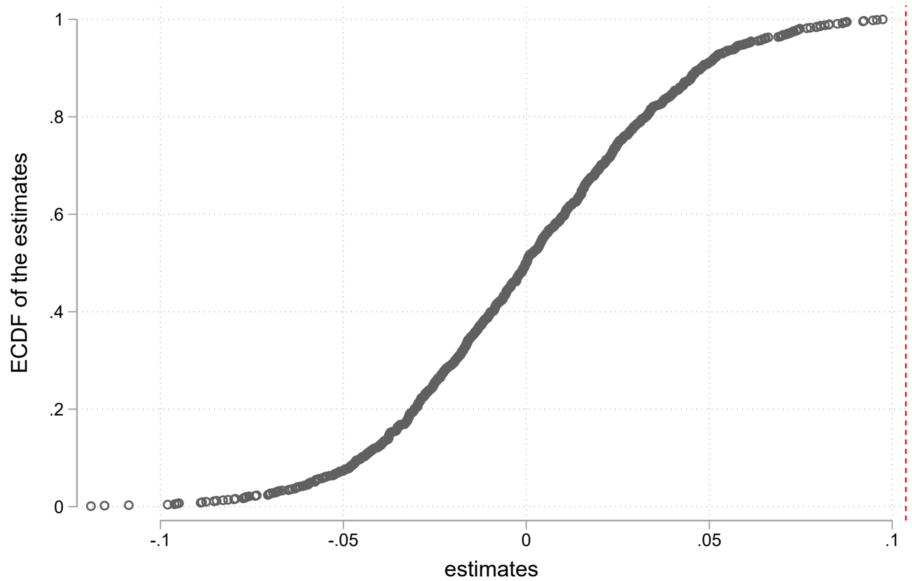
Notes: The figure presents the event study coefficients estimated using TWFE and corresponding to Table 8 (Column 3). The outcome is NTL intensity, measured as the log sum of NTL intensities, on the *Africapolis* built-up area with a 2-kilometer buffer. Confidence intervals are drawn at the 95% level using standard errors clustered at the level of the closest access point.

Figure E.14: Model specification: Staggered treatment (TWFE) II



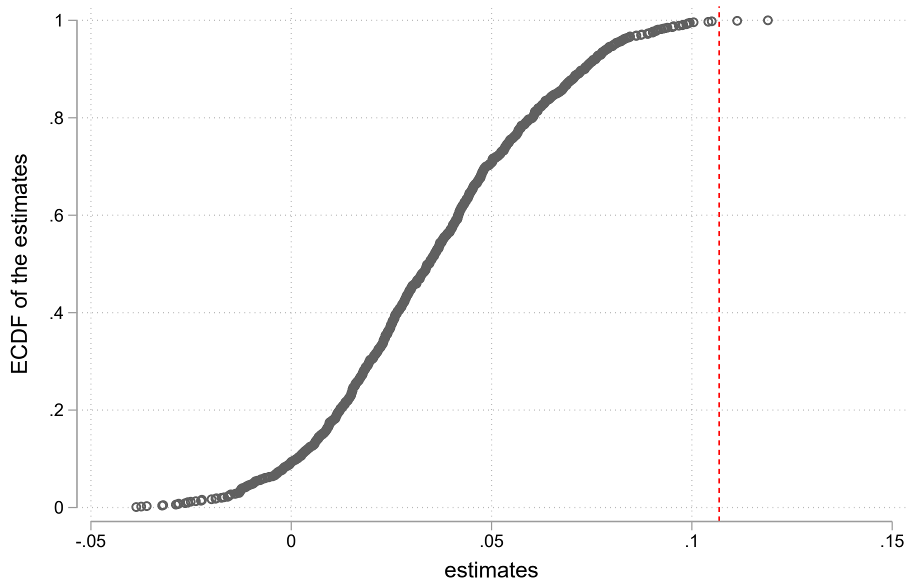
Notes: The figure presents the event study coefficients estimated using TWFE and corresponding to Table 8 (Column 6). The outcome is NTL intensity, measured as the log sum of NTL intensities, on the *Africapolis* built-up area with a 2-kilometer buffer. Confidence intervals are drawn at the 95% level using standard errors clustered at the level of the closest access point.

Figure E.15: Omitted variables: 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 2 (Column 3) with randomly assigned treatment status. The vertical line represents the true estimate.

Figure E.16: Omitted variables: 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 2 (Column 3) with randomly assigned connection years. The vertical line represents the true estimate.

Appendix F. Early national backbone deployment projects

Table F.1: Source register backbone deployment, pre-2009

Country	City/town	Connection	URL source
Angola	Benguela	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	Cabinda	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	Dondo	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	N'dalatando	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	Sumbe	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	Chibia	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	Lubango	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	Luanda	2001	https://www.submarinenetworks.com/en/systems/euro-africa/sat-3
Angola	Malanje	2009	https://www.linkedin.com/pulse/how-angola-got-its-first-workable-fiber-network-osvaldo-coelho
Angola	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
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

Table continues on the next page.

Country	City/town	Connection	URL source
Burkina Faso	Tenkodogo	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Koupéla	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Koudougou	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Fada N'Gourma	2009	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Bobo Dioulasso	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Orodara	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Burkina Faso	Zorgho	2005	https://www.itu.int/en/ITU-D/LDCs/Documents/2017/Country%20Profiles/Country%20Profile_Burkina%20Faso.pdf
Cameroon	Meiganga	2005	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Cameroon	Bafia	2009	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Cameroon	Yaounde	2005	https://www.researchictafrica.net/countries/cameroon/Sector_Strategy_for_Telecommunications_and_ICT_2005-2015.pdf
Cameroon	Mbalmayo	2009	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Cameroon	Bélabo	2005	https://www.researchictafrica.net/countries/cameroon/Sector_Strategy_for_Telecommunications_and_ICT_2005-2015.pdf
Cameroon	Edéa	2005	https://www.researchictafrica.net/countries/cameroon/Sector_Strategy_for_Telecommunications_and_ICT_2005-2015.pdf
Cameroon	Douala	2001	https://www.submarinenetworks.com/en/systems/euro-africa/sat-3
Cameroon	Bamenda	2009	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Cameroon	Kribi	2005	https://www.researchictafrica.net/countries/cameroon/Sector_Strategy_for_Telecommunications_and_ICT_2005-2015.pdf
Cameroon	Limbe	2009	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Cameroon	Bafang	2009	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Cameroon	Bafoussam	2009	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Chad	Doba	2005	https://www.researchictafrica.net/countries/cameroon/Sector_Strategy_for_Telecommunications_and_ICT_2005-2015.pdf
Chad	Ndjamena	2009	http://blog.gelgabon.net/2010/01/cameroun-fibre-optique-fibre-de_23.html
Côte d'Ivoire	San-Pedro	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Sassandra	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27296
Côte d'Ivoire	Soubré	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Aboisso	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Gagnoa	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Divo	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Toumodi	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27296
Côte d'Ivoire	Yamoussoukro	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Dimbokro	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Abidjan	2001	https://www.submarinenetworks.com/en/systems/euro-africa/sat-3
Côte d'Ivoire	Man	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Guiglo	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Daloa	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Bouaflé	2005	https://idl-bnc-idrc.dspacedirect.org/handle/10625/27295
Côte d'Ivoire	Ferkessédougou	2008	http://malijet.com/a_la_une_du_mali/7721-mali-c_te_d_ivoire_interconnexion_de_la_fibre_optique.html
Côte d'Ivoire	Bouaké	2008	http://malijet.com/a_la_une_du_mali/7721-mali-c_te_d_ivoire_interconnexion_de_la_fibre_optique.html
Djibouti	Ali Sabieh	2007	https://www.submarinenetworks.com/en/systems/eurasia-terrestrial/renovation-of-the-djibouti-ethiopia-digital-corridor
Djibouti	Galafi	2007	https://www.submarinenetworks.com/en/systems/eurasia-terrestrial/renovation-of-the-djibouti-ethiopia-digital-corridor
Djibouti	Djibouti	1999	https://web.archive.org/web/20081222095315/http://www.heise.de/tp/r4/artikel/5/5245/1.html
Eritrea	Mendefera	2009	https://en.wikipedia.org/wiki/EASSy

Table continues on the next page.

Country	City/town	Connection	URL source
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
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

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Country	City/town	Connection	URL source
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/

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Country	City/town	Connection	URL source
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/
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

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Country	City/town	Connection	URL source
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
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/

Table continues on the next page.

Country	City/town	Connection	URL source
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

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Country	City/town	Connection	URL source
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

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Country	City/town	Connection	URL source
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
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

Table continues on the next page.

Country	City/town	Connection	URL source
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
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

Table continues on the next page.

Country	City/town	Connection	URL source
Tanzania	Kilosa	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Morogoro	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Kibiti	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Manyoni	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Singida	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Tabora	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Tanzania	Tanga	2009	http://ijcir.mak.ac.ug/volume10-issue1/article6.pdf
Togo	Sokodé	2005	https://books.google.de/books?id=Hqt8eQNuRaoC&pg=PA41&lpg=PA41&dq=fiber+optic+cable+togo+burkina+faso+2006&source=bl&ots=A-zya4sPwq&sig=ACfU3U0Lv-bGFR3LrEJmvI7ir-7JI1NS3A&hl=de&sa=X&ved=2ahUKEwi6-4WpxIbqAhXKjqQKHcR0CbAQ6AEw-AHoECAcQAQ#v=onepage&q=fiber%20optic%20cable%20togo%20burkina%20faso%202006&f=false
Togo	Sotouboua	2005	https://books.google.de/books?id=Hqt8eQNuRaoC&pg=PA41&lpg=PA41&dq=fiber+optic+cable+togo+burkina+faso+2006&source=bl&ots=A-zya4sPwq&sig=ACfU3U0Lv-bGFR3LrEJmvI7ir-7JI1NS3A&hl=de&sa=X&ved=2ahUKEwi6-4WpxIbqAhXKjqQKHcR0CbAQ6AEw-AHoECAcQAQ#v=onepage&q=fiber%20optic%20cable%20togo%20burkina%20faso%202006&f=false
Togo	Lomé	2005	https://books.google.de/books?id=Hqt8eQNuRaoC&pg=PA41&lpg=PA41&dq=fiber+optic+cable+togo+burkina+faso+2006&source=bl&ots=A-zya4sPwq&sig=ACfU3U0Lv-bGFR3LrEJmvI7ir-7JI1NS3A&hl=de&sa=X&ved=2ahUKEwi6-4WpxIbqAhXKjqQKHcR0CbAQ6AEw-AHoECAcQAQ#v=onepage&q=fiber%20optic%20cable%20togo%20burkina%20faso%202006&f=false
Togo	Atakpamé	2005	https://books.google.de/books?id=Hqt8eQNuRaoC&pg=PA41&lpg=PA41&dq=fiber+optic+cable+togo+burkina+faso+2006&source=bl&ots=A-zya4sPwq&sig=ACfU3U0Lv-bGFR3LrEJmvI7ir-7JI1NS3A&hl=de&sa=X&ved=2ahUKEwi6-4WpxIbqAhXKjqQKHcR0CbAQ6AEw-AHoECAcQAQ#v=onepage&q=fiber%20optic%20cable%20togo%20burkina%20faso%202006&f=false
Togo	Mango	2005	https://books.google.de/books?id=Hqt8eQNuRaoC&pg=PA41&lpg=PA41&dq=fiber+optic+cable+togo+burkina+faso+2006&source=bl&ots=A-zya4sPwq&sig=ACfU3U0Lv-bGFR3LrEJmvI7ir-7JI1NS3A&hl=de&sa=X&ved=2ahUKEwi6-4WpxIbqAhXKjqQKHcR0CbAQ6AEw-AHoECAcQAQ#v=onepage&q=fiber%20optic%20cable%20togo%20burkina%20faso%202006&f=false
Uganda	Kampala	2009	https://www.commsupdate.com/articles/2006/06/13/mtn-uganda-extends-fibre-optic-network/
Uganda	Masaka	2009	https://www.commsupdate.com/articles/2006/06/13/mtn-uganda-extends-fibre-optic-network/
Uganda	Entebbe	2009	https://www.commsupdate.com/articles/2006/06/13/mtn-uganda-extends-fibre-optic-network/
Uganda	Busia	2009	https://www.commsupdate.com/articles/2009/07/07/kdn-builds-out-seacom-link/
Uganda	Jinja	2009	https://www.commsupdate.com/articles/2006/06/13/mtn-uganda-extends-fibre-optic-network/
Uganda	Tororo	2009	https://www.commsupdate.com/articles/2009/07/07/kdn-builds-out-seacom-link/
Uganda	Mbarara	2009	https://www.commsupdate.com/articles/2006/06/13/mtn-uganda-extends-fibre-optic-network/
Zambia	Kabwe	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Kapiri Mposhi	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Chililabombwe	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Chingola	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Kitwe	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Luanshya	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Mufulira	2009	https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.scribd.com%2Fdocument%2F274569230%2FZe-Scoop-Tic-Phase-i-i-20062012&psig=AOvVaw3VnkgSbaRyyBKkKOcAVBcN&ust=1593259795755000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCNCu1MC5n-oCFQAAAAAdAAAAABAY
Zambia	Ndola	2009	https://www.google.com/url?sa=i&url=https%3A%2F%2Fwww.scribd.com%2Fdocument%2F274569230%2FZe-Scoop-Tic-Phase-i-i-20062012&psig=AOvVaw3VnkgSbaRyyBKkKOcAVBcN&ust=1593259795755000&source=images&cd=vfe&ved=0CAIQjRxqFwoTCNCu1MC5n-oCFQAAAAAdAAAAABAY
Zambia	Lusaka	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Solwezi	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html
Zambia	Choma	2007	https://www.networkworld.com/article/2278133/zesco-to-complete-zambia-fiber-backbone.html

Table continues on the next page.

Country	City/town	Connection	URL source
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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