The Arrival of Fast Internet and Skilled Job Creation in Africa*

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Abstract

This paper provides evidence on the causal effect on job creation of the expansion of fast Internet along its current frontier in developing countries. We exploit the gradual arrival in African coastal cities of submarine Internet cables from Europe and maps of the continent's terrestrial cable network that connects those cities with users. Robust difference-in-differences estimates from three datasets covering 14 countries show large average effects on employment rates. Fast Internet enables the creation of skilled jobs but reduces employment rates in some unskilled occupations; increases firm creation in technological sectors; and increases business ownership among individuals. The reduced form effects appear to be driven both by an increase in average speeds for existing users and increased take-up. In ongoing work, we further unpack the mechanisms underlying increased job creation by estimating production functions using a panel dataset of existing manufacturing firms. Our findings shed light on the barriers to job creation in African firms, and encourage emphasis on building Internet infrastructure in developing countries.

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1 Introduction

To some, the Internet is the greatest invention of our time (The Economist, 2012). Proponents argue that fast Internet can reduce search and communication frictions, enable the use of advanced production systems, and lower entry barriers. If so, the technology may help to "unleash" the private sector and increase job creation in the developing world, where investment in high-speed infrastructure has begun in some regions while others lag behind. However, the effect of fast Internet on job creation depends on its factor bias in the relevant context, and on the existing distribution of skills, other factors of production, and interacting constraints. Indeed, some new technologies lead to net job losses in regions with many jobs that can be automated and replaced by those technologies (Autor *et al.* , 1998).

In this paper we attempt to provide the first causal estimates of the magnitude of and mechanisms underlying the impact of fast Internet on job creation in developing countries. To do so we compare individuals and firms in locations in Africa that are on the terrestrial network of Internet cables to those that are not during the gradual arrival in coastal cities of submarine cables from Europe that greatly increase speed capacity on the terrestrial network. We investigate the technology's skill bias in Africa by decomposing the effect on overall job creation into changes in skilled and unskilled employment rates, and explore extensive margin (increased take-up) versus intensive margin (increased speed) contributions to the reduced form effects. To understand how fast Internet increases job creation, we first show how net births of new firms of different types and business ownership is affected. In ongoing work, we are using a more detailed firm level panel dataset that allows us to estimate production functions in order to understand the increased job creation in existing firms. Our results enhance our understanding of the constraints and possibilities facing African firms, and speak to the optimal level and targeting of investment in Internet infrastructure in poor countries.

Given the level of policy interest in increasing access to fast Internet in developing countries (see e.g. World Bank, 2016), it is clear that the lack of evidence on its economic impact is not due to a lack of demand. Supplying such evidence has been difficult most obviously because new Internet infrastructure is presumably not randomly allocated, but built where economic benefits are expected. Systematic and detailed labor market and, especially, firm level datasets that cover many or large developing countries are also rare. We overcome the first obstacle by interacting time variation generated by the gradual arrival of 10 submarine Internet cables from Europe in landing point cities on Africa's coast between 2007 and 2013 with cross-sectional variation in whether a given location is covered by the terrestrial "backbone" network that starts at the landing point cities. That a given submarine cable reaches different countries at different times and in a geographically determined order, and that we consider 10 different cables, a priori lowers concerns about non-parallel prior trends in employment rates for locations on versus off the backbone network. As importantly, the *large-T* datasets we use enable an extensive battery of tests – including direct inspection of pre-trends – that support a causal interpretation of our results.

We overcome the second obstacle by combining employment data from a large and diverse set of African countries with more detailed country-specific datasets. The employment data that we use to estimate the effects of access to fast Internet on overall, skilled, and unskilled job creation comes from household surveys (unbalanced panels at location level) from 14 African countries.[1] We use detailed labor force, firm ownership, firm registration, and firm surveys data (balanced panels at location or firm level) from South Africa and Ethiopia to probe the identifying assumptions and to explore the mechanisms underlying effects on

[1]One dataset covers Benin, D.R. Congo, Ivory Coast, Liberia, Nigeria, Senegal, Sierra Leone, Tanzania, and Togo, and the other Benin, Ghana, Kenya, Madagascar, Mozambique, Nigeria, Senegal, South Africa, and Tanzania.

net job creation in depth. Using the Ethiopian panel dataset of large and medium manufacturing firms, we estimate production functions and compute the returns to, and interactions between, different input factors, which allows us to unpack Internet's underlying skill bias in Africa. We also use data on speed and use of the Internet to tie the reduced form estimates to the immediate effects of the infrastructure build-out.

We find that access to fast Internet increases the probability that an individual is employed by 1.9 and 3.7 percent respectively in the two groups of countries covered by our household survey datasets, and by 1.5 percent in South Africa. While employment responses of such magnitude indicate that building fast Internet infrastructure is among the currently available policy options with the greatest job creating potential in Africa, Atasoy (2013) and Gillett *et al.* (2006) actually find correlations of similar or slightly smaller magnitude in rural and isolated areas of the U.S. When breaking down employment by occupation, we find especially large effects on being employed in professional, sales and services jobs, but a decrease in clerical and "elementary" employment, also in line with findings from rich countries (Autor *et al.* , 1998, 2003; Katz & Margo, 2014). To investigate how fast Internet affects job creation, we first show that both average speeds and take-up of the Internet increased in connected areas, relative to unconnected areas, after submarine cable arrival. We then analyze both how business ownership and net firm creation respond, and how productivity and the output returns to workers of different types in existing firms are affected. We find a significant increase in business ownership and in net births of new technological firms, but no effect on overall or manufacturing firm creation. [TBA: FINDINGS FROM STRUCTURAL ANALYSIS].

This paper contributes to the literatures on economic consequences of the Internet; firms in developing countries; and new technologies and their skill bias. Economists studying the economic effects of fast Internet have typically focused on correlations with local wage levels in rich countries (see e.g. Czernich. *et al.* , 2011; OECD, 2013); country-level economic growth rates;[2] or firm profits[3] – and found positive associations.[4] Akerman *et al.* (2015) is an exception in that the authors use a research design explicitly intended and well-suited to identify causal effects in a broad sample of workers and firms. They show that, in Norway, the build-out of broadband Internet led to an increase in the wages and productivity of high-skill workers. Of course, we may expect a different economic impact in developing countries where the Internet represents a bigger technological advance; information frictions are severe; the distribution of skills and other complementary inputs differs; and where unemployment rates are high. We are not aware of any existing causal evidence on the impact of the Internet in developing countries.

The literature on firms in developing countries has made considerable progress in the last decade. The benefits to firms of exporting (see e.g. Goldberg *et al.* , 2010) or winning government contracts (Ferraz *et al.* , 2015) illustrates the importance of the size of the markets that can be accessed, even conditional on initial productivity. Lowering information frictions may increase trade between regions (Allen, 2014),[5] and how efficiently demand is distributed across firms (Jensen, 2007). Increased demand has in turn been shown to enable firms to learn and to produce higher quality products that may require hiring more skilled workers (Verhoogen, 2008; Atkin *et al.* , 2015). Existing evidence also indicates that improved coordination with

[2] Qiang & Rossotto (2009) run a cross-country growth regression and find that a 10 percent increase in broadband penetration is associated with a 1.38 percentage point higher GDP per capita growth rate in developing countries.

[3] Varian *et al.* (2002) argue that Internet business solutions have enabled private companies to cut costs by USD 155 billion in the United States.

[4] Atasoy (2013) is an exception in that the author, like this paper, studies effects of the Internet on job creation. She finds that a U.S. county gaining access to broadband services is associated with a 1.8 percentage points higher employment rate, with larger effects in rural and isolated areas, among college-educated workers, and in industries and occupations that more heavily utilize college-educated workers. She argues that the findings are explained by the expansion of existing firms and an increased size of the labor force ex post. Champion *et al.* (2012) also find a positive correlation between Internet access and labor supply in the U.S.

[5] Clarke & Wallsten (2006) find that a 1 percentage point increase in the number of Internet users is associated with 3.8 percentage points higher exports from low-income to high-income countries.

suppliers can enhance firms' performance (Macchiavello & Miquel-Florensa, 2015), and that ICT technologies can encourage productive organizational change.[6] Despite such important strides, however, firms in developing countries remain remarkably poorly understood. Studies that demonstrate *specific* ways that policymakers can facilitate firm growth are especially rare. Our contribution is to demonstrate how access to fast Internet affects the performance of and jobs created by African firms.[7]

A sizable existing literature explores the consequences for inequality and rich countries' labor markets of skill-biased technological change, in recent years focusing especially on the factor complementarity of ICT and Internet-based technologies. For example, the relative demand for college graduates has been shown to increase since the late 1980s with take-up of computers in the U.S. (Krueger, 1993; Autor *et al.* , 1998; Bartel & Sicherman, 1999; Autor *et al.* , 2003),[8] and with fast Internet in Norway (Akerman *et al.* , 2015). Recent technological change in the U.S. also appears to have favored female workers (Katz & Murphy., 1992; Black & Spitz-Oener, 2010; Champion *et al.* , 2012), while the evidence is mixed on the relative wage impacts in richer and poorer U.S. counties.[9] In this paper we document the skill bias – focusing primarily on job creation – of fast Internet in Africa, where the technology may be (even) more transformational relative to the status quo.

The rest of the paper is organized as follows. In Section 2 we lay out the background on Internet and jobs in Africa, and discuss some examples of job creation often attributed to the arrival of the submarine cables. In Section 3 we present our data, and in Section 4 the empirical strategy. The paper's main results are in Section 5, and in Section 6 we disentangle the underlying mechanisms. Section 7 concludes.

2 Background

2.1 Internet technology and use in Africa

In 2000, Africa as a whole had less international Internet bandwidth than the country of Luxembourg (ITU, 2000). Since then, Internet access has increased rapidly. By 2013, 13 percent of all Africans used the Internet, compared to 36 percent globally (Internet Society, 2013), and more than half of urban Africans had Internet-capable devices (McKinsey Global Institute, 2013). Listed in decreasing order of average speeds and increasing order of frequency in Africa, the forms of Internet infrastructure that reach consumers – the "last mile" – are fiber cables, copper cables, wireless transmission using cell towers, and satellites (de M. Cordeiro *et al.* , 2003; Gallaugher, 2012). Prior to the last mile, Internet traffic travels through a national

[6] The evidence on ICT technologies and changes in the organization of production comes from rich countries – see e.g. Bresnahan *et al.* (2002); Bartel *et al.* (2007); Bloom *et al.* (2012).

[7] There is a large literature exploring correlations between Internet access and firm outcomes in developing countries. For example, Paunov & Rollo (2015) find that industries' use of the Internet correlate positively with firm performance in a range of poor countries; Basant *et al.* (2011), using more detailed data on Brazilian and Indian firms, find the same for ICT technologies. See also Katz (2012) and Qiang & Rossotto (2009).

[8] Krueger (1993) find that the spread of computers in the U.S. in the 1980s increased wages for workers that use a computer, and increased returns to education. Acemoglu & Autor (2011) and Michaels *et al.* (2014) find that ICT technologies are complementary to high-skill workers, but substitute for middle-skill workers in rich countries. Katz & Murphy. (1992) show that, before the late 1980s, secular growth in the demand for more-educated, more-skilled, and female workers was the driving force behind changes in the wage structure, while Katz & Margo (2014) find that in the U.S. "the employment share of high skill occupations (professional, technical, and managerial) has increased steadily from 1850 to the present." (Katz & Margo, 2014, p. 7). Bartel & Sicherman (1999) find that the wage premium associated with technological change is partly due to the sorting of better workers to industries that upgrade technologically.

[9] Forman *et al.* (2012) find that advanced Internet technology is only associated with substantial wage growth in those U.S. counties that were already highly wealthy, educated, populated, and had IT-intensive industry. Champion *et al.* (2012); Atasoy (2013) find bigger impacts in rural and/or remote areas.

"backbone" of bigger (typically fiber) cables, as depicted in Figure I for South Africa.[10] The backbone was built by a national telecom in almost all countries, sometimes with "branches" added by private telecoms. Since Internet traffic was initially transmitted through telephone cables, the majority of the backbone network cables date back many decades (ITU, 2013).

In the 2000s, submarine Internet cables to Africa from Europe were built by consortia made up of private investors, African governments, and/or multilateral organizations (OECD, 2014).[11] The submarine cables were brought to shore at various landing points along the coast, often one in each country passed by the cable. These were usually located just outside of a big city that was connected to the national backbone, such as Mombasa in Kenya. Figure II shows the 10 submarine cables that arrived in Africa during our data period,[12] as defined in Mahlknecht (2014)'s map of submarine cables.

Once plugged in, the submarine cables brought much faster speed capacities on Internet traffic to and from Europe and other continents to locations in Africa connected to the terrestrial network.[13] On a fiber-optic cable network, the technologically feasible increase in traffic and speeds post-submarine cable plug-in decays with cable length to the landing point to a negligible extent. In general, technological bottlenecks therefore arise at the backbone level only where networks owned by different owners connect to each other. In such cases, the Internet service providers (ISPs) operating on network A will transmit content to network B directly only if the two networks are not only physically connected, but also collaborating, for example through "peering" (ITU, 2013).[14] If not, the fees that African networks charge each other for the exchange of traffic ("transit") are such that content stored on network A would likely be sent via Europe to users on network B ("tromboning"). While this partly explains the submarine cables' predicted effect on "experienced" speed, a more important fact is that much of content that African users access – email servers, the websites of African businesses, etc – is "hosted" by (stored on) servers in Europe and other continents. For example, Chavula *et al.* (2014) found that on average 75 percent of the traffic originating in Africa that is destined for African universities traverse links outside the continent, and Kende & Rose (2015) report that all of the top 14 commercial websites in Rwanda are hosted in Europe or the U.S.

Kende & Rose (2015) conclude that the "evidence suggests that in Africa very little Internet content is sourced locally, with the vast majority sourced internationally – including local content that is hosted overseas." (Kende & Rose, 2015, p. 15).[15] This fact that is important for this paper. In combination with each country being covered by a single backbone network, the lack of "spillovers" from one coastal country's submarine connection to neighboring countries means that each country has a specific "treatment date" for a given submarine cable – the date when the cable has arrived at the country's landing point and is plugged in.[16]

[10] Some experts include a "middle mile" (that carries traffic e.g. from telephone exchanges or mobile base stations to central switching locations) in their categorizations of Internet infrastructure.

[11] One of the 10 submarine cables that arrived in Africa during our data period connected the continent with both Europe and India, another one connected Africa with the U.A.E. We refer to the connection point of the submarine cables outside of Africa collectively as "Europe" for simplicity.

[12] We have data on Internet speed from the third quarter of 2007 to the first quarter of 2014. The cables that arrived in Africa during this period are the following: ACE, EASSy, GLO-1, Lion1 and Lion2, MaIN OnE, Seacom1 and Seacom2, TEAMs and WACS.

[13] Being reached by submarine Internet cables from Europe implies a faster connection also to North America and other continents because of the extensive Internet infrastructure that connects Europe with other continents.

[14] Peering means that two networks exchange traffic free of charge. A location in which many networks are peering with each other simultaneously is called an Internet Exchange Point (IXP). Note also that an ISP is usually the same company that owns the cables used.

[15] The main reason is cost: "one content developer reported spending USD 49.99 per year for up to 150GB capacity overseas, compared to a Rwandan offer of over USD 900 for 50GB capacity" (Kende & Rose, 2015, p. 3). But the content developers' decision to host abroad imposes additional costs on African ISPs for carrying the associated traffic: Africa pays over USD 600 million a year for within-Africa traffic exchange that is carried outside the continent (Internet Society, 2013).

[16] Note that we exclude landlocked countries from our analysis because it is unclear whether they get treated (though coastal neigh-

On top of the technological determinants of Internet capacity in a given location are, of course, "I.O." and regulatory determinants of user access and use. For example, countries differ in whether they force backbone cable owners to lease out use of their cables also to competing ISPs, which tends to lower prices and increase access.

In Table I we illustrate the variation in speeds and use of the Internet across African countries, focusing on the period before the submarine cables arrived. Average (measured) speeds ranged from 5.12 KB/sec in Kenya to 6.52 KB/sec in South Africa. These are very slow speeds; "broadband" is, for example, usually defined as having download speed capacity exceeding 256 KB/sec. Individuals' take-up rates ranged from 8 percent in Madagascar and Tanzania to 40 percent in Nigeria. In Section 3 we describe the data in detail; some limitations of the speed measure are discussed in Sub-section 5.1.

2.2 Jobs in Africa

Given the diversity of the 14 countries in our sample, we do not attempt to describe an "average" African labor market here. Instead Table II displays, for each country in our sample and focusing again on the period before fast Internet arrived: the proportion of individuals that are employed; employed in a skilled job; and employed in an unskilled job. The overall employment rate varies from 39 percent in Senegal to 82 percent in Benin. We observe the type of occupation that an individual is employed in only for the countries in the DHS and QLFS samples. In D.R. Congo, Liberia and Sierra Leone, the skilled employment rate is 6, 3 and 7 percent respectively, while the unskilled employment rate ranges from 48 to 63 percent in these especially poor countries. In Nigeria, Tanzania and South Africa, the skilled employment rate is around 15 percent, while the unskilled employment rate ranges from 26 percent in South Africa to 60 percent in Tanzania.

It is worth noting that the 2007 – 2014 period we focus on was a period of high GDP per capita growth in many African countries. In his book on 17 newly "emerging" African countries, Radelet (2011) includes seven of the 16 countries in our sample. Radelet argues that the unusually high growth rates since the late 1990s in the 17 countries he focuses on are explained by a combination of democratization, improved economic policies, debt reduction, new technologies, and a new generation of energetic leaders. However, some countries in our sample, especially South Africa, were badly affected by the 2008 global financial crisis.

2.3 Examples of new job creation after the arrival of fast Internet

There are many articles in the media and case studies of new, and new types, of jobs in Africa being created after the arrival of fast Internet. Scruggs (2015) reports that "In 2009, a submarine fiber optic cable landed on the beaches of Mombassa [...] Six years later, Nairobi is bursting with technology startups like Shop Soko, a sort of Etsy for Africa that allows shopkeepers to sell handmade goods to consumers worldwide. The Kenyan capital has also emerged as [a] base for high-tech heavyweights such as Google, IBM and Intel. From 2002 to 2010, the value of Kenya's tech exports rose from USD 16 million to USD 360 million. In Nairobi's Kilimani neighborhood, where the tech scene is centered, ten-story office buildings clad in glass are shooting up everywhere." Kilimani is home to the iHub incubator, which, according to McKinsey Global Institute (2013), had helped develop more than 150 new tech businesses by 2013.[17] Similarly, Harris (2012) reports that "With the landing of new submarine telecom cables off South Africa's coastline starting with Seacom in 2009, bandwidth prices began to tumble, removing one of the most significant barriers to the

bors) or not.

[17] Other new incubators in Africa include South Africa's JoziHub, Cameroon's ActivSpaces, and Nigeria's CcHub and Wennovation Hub (McKinsey Global Institute, 2013).

global competitiveness of the country's IT industry. That was a catalyst for the explosion of Cape Town's tech scene [...] Thanks to its growing stature as a business process outsourcing [BPO] and offshoring hub, the Western Cape has drawn investment from a range of international companies over the past few years, among them Amazon, the UK's Serco, and India's WNS." In 2013 there were more than 54,000 jobs in South Africa's new BPO sector, and Morocco's was at similar scale (McKinsey Global Institute, 2013).

In Nigeria, eCommerce has taken off, driven in part by major online retailers such as Konga and Jumia (Rice, 2013),[18] which also operate in Egypt, Ivory Coast, Kenya, and Morocco. Online purchases in Nigeria stood at more than USD 1 billion in 2014, tripling in three years (Atuanya & Augie, 2013). Adepetun (2014) of the online news site AllAfrica.com argues, based on interviews with officials and industry executives, that Nigeria's ICT sector created 100,000 direct jobs from 2004 to 2014, and 1.1 million jobs indirectly, increasing its contribution to the country's services sector from 0.04 to 19 percent, and that eCommerce and ICT's success in Nigeria is due in part to greater access to bandwidth due to the arrival of the submarine cables.

Kenya, Nigeria and South Africa all now have a manufacturing sector producing Internet-capable devices for the African market, such as low-cost cell phones, laptops, and tablets (McKinsey Global Institute, 2013).

The arrival of fast Internet also appears to have made coordination along the supply chain easier. For example, Mozambican moWoza and several similar start-ups in other African countries use smartphone apps and websites to deploy taxi drivers and others to deliver parcels from wholesalers to traders (McKinsey Global Institute, 2013), and all bureaucracy required to import in Ghana can now be done online, which has decreased delays considerably [REF].

Tech start-ups, BPO, eCommerce, new forms of manufacturing, and innovative companies and regulatory agencies that make doing business easier for other firms are of course only examples of the ways in which fast Internet may enable greater job creation. Conversely, by enabling automation, fast Internet may have reduced employment in some occupations, or conceivably even on average. In the next section we present the data that we use to investigate the average effect of the arrival of fast Internet on job creation in Africa, and the underlying mechanisms.

3 Data

Our outcome data comes from the following sources:

Demographic and Health Surveys (DHS) DHS surveys are nationally representative repeated cross-sections. The order in which sampling clusters are surveyed is randomly determined. GPS coordinates for sampling clusters are recorded. Women between 15 and 49 years old are interviewed. The survey asks questions about labor market participation, health, and demographic background. We use DHS data from coastal countries that had survey rounds both before and after submarine cable arrival in the relevant country: Benin, D.R. Congo, Ivory Coast, Liberia, Nigeria, Senegal, Sierra Leone, Tanzania, and Togo.

From DHS we construct outcome variables for the individual being employed,[19] as well as her being employed in a specific type of occupation. We also use educational attainment and other background variables.

[18](Rice, 2013) reports that "entrepreneur Sim Shagaya founded [online retailer] Konga [in 2012]. Today [in 2013] the company has 150 employees and a large warehouse in Lagos [...] After going live in June [2012], [online retailer] Jumia now employs 350 people in Nigeria. The site gets close to 100,000 unique visitors a day" (Rice, 2013).

[19]The question states "Aside from your own housework, have you done any work in the last seven days?".

Afrobarometer Afrobarometer surveys are nationally representative repeated cross-sections conducted every two – three years in many African countries. The order in which sampling clusters are surveyed is randomly determined. Location information for sampling clusters is recorded. Men and women of voting age are interviewed. The survey asks socioeconomic questions, and records opinions about a range of political topics. We use Afrobarometer data from coastal countries that had survey rounds both before and after submarine cable arrival in the relevant country: Benin, Ghana, Kenya, Madagascar, Mozambique, Nigeria, Senegal, South Africa, and Tanzania.

From Afrobarometer we construct an outcome variable for the individual being employed.[20] We also use educational attainment and other background variables.

South Africa Quarterly Labor Force Survey (QLFS) The South Africa Quarterly Labour Force Survey is a nationally representative repeated cross-section at individual worker level, and a balanced panel at enumeration area level. The current version of the survey began in 2008.

We construct QLFS outcome variables that as far as possible correspond to the ones used in the DHS, namely whether the individual is employed,[21] and whether he/she is employed in a specific type of occupation. We also use an indicator for the individual owning a business, and educational attainment and other background variables.

South Africa Companies and Intellectual Property Commission (CIPC) Firm Registry South African companies are required to register with CIPC. The resulting zip-code×date level panel registry of firm registrations and de-registrations captures the net flow of firms in existence. We additionally code up each firm's sector when its name contains sufficient information to do so.[22]

Ethiopia Large and Medium Scale Manufacturing Industries Survey (LMMIS) LMMIS is an annual survey of the universe of Ethiopian manufacturing establishments that engage 10 or more persons and use power-driven machines. The survey collects information about employees, inputs, production, sales, and assets, and is used to construct the country's national accounts.

From LMMIS we construct an outcome variable for the number of employees per firm. [TBA: OUTPUT, INPUTS, CAPITAL, AND OTHER VARIABLES BEING USED IN PRODUCTION FUNCTION ESTIMATION]

We also use Internet infrastructure and speed data:

Maps We use Mahlknecht's map of submarine cables to measure landing points and -times (Mahlknecht, 2014), and AfTerFibre's map of terrestrial backbones to measure inland locations' connectedness (AfTerFibre, 2014).[23]

[20] The question states "Do you have a job that pays a cash income?". Afrobarometer does not record the type of occupation an individual is employed in.

[21] The question states "In the last week, did you work for a wage, salary, commission or any payment in kind (including paid domestic work), even if it was only one hour?".

[22] We were able to assign a category to 60 percent of the firms.

[23] Note that we consider Ethiopia (eventually) treated because it is well-documented that the country's backbone became internationally connected via Djibouti's submarine cable soon after it landed, which was viable only by covering also Ethiopia (Giorgis, 2010; Oxford Business Group, 2015). We also consider all landing point cities connected.

Akamai Internet speeds data Akamai, Technologies, Inc. is a "content delivery network" (CDN) that owns servers all over the world and serves between 15 and 30 percent of all Internet traffic. The company measures location ("city")×quarter level speeds by averaging the speeds recorded for users in a given location×quarter who test their connection using Akamai's speed test website. (We discuss an important limitation of this measurement method in Sub-section 5.1). Akamai provided us with quarterly data on average and peak connection speeds for ∼900 African locations during the 2007 – 2013 period.

4 Empirical Strategy

Our primary focus is on the reduced form relationship between job creation in a given location and time period on the one hand and whether or not the location is connected to submarine Internet cables from Europe via the terrestrial backbone network on the other. We run

$$Y_{i\mathbf{j}(i)t} = \alpha + \beta \text{SubmarineCables}_{\mathbf{j}(i)t} + X_{i\mathbf{j}(i)t}\pi + \delta_{\mathbf{j}(i)} + \gamma_t + \epsilon_{i\mathbf{j}(i)t} \quad (1)$$

where $Y_{i\mathbf{j}(i)t}$ is an outcome for individual i in grid-cell $\mathbf{j}(i)$ and time period t, $X_{i\mathbf{j}(i)t}$ is a set of individual and location level controls,[24] $\delta_{\mathbf{j}(i)}$ are 0.2×0.2 degree (∼20×20 km) grid-cell fixed effects, γ_t are time period (quarter or year) fixed effects,[25] and $\text{SubmarineCables}_{\mathbf{j}(i)t}$ is equal to the number of submarine cables that location $\mathbf{j}(i)$ is connected to at t. The $X_{i\mathbf{j}(i)t}$ help control for possible changes in the sample surveyed across time/space, and the location and time period fixed effects for any time- or location-invariant shocks to employment outcomes that may be correlated with Internet connectivity. The standard errors are clustered at the grid-cell level.

We define a location as "connected" if it is near terrestrial Internet infrastructure that enables transmission of broadband speeds, as in Akerman *et al.* (2015). (We refer to a location as "treated" at t if additionally at least one submarine cable has arrived in the country at t). That is, $\text{SubmarineCables}_{\mathbf{j}(i)t} = 0$ for a location $\mathbf{j}(i)$ that is not on the backbone network. For a location that is on the backbone network, $\text{SubmarineCables}_{\mathbf{j}(i)t} = 1$ when the first submarine cable has arrived in the country, $= 2$ when the second cable has arrived, and so on. Using South Africa as an example, Figure I displays the grid-cells that we use to define location fixed effects, the country's backbone network, as well as dots that represent the QLFS enumeration areas.

In Sub-section 2.1 we discussed how the technologically feasible increase in traffic and speeds post-submarine cable arrival decays with cable length along the fiber-optic backbone networks to a negligible extent. A location's connectivity *does* decay with distance to the backbone network, but the connectivity reach beyond the backbone network depends on the last mile infrastructure in place in a given area (Commonwealth Telecommunications Organisation, 2012; Banerji & Chowdhury, 2013). Since we lack information on last mile infrastructure at the local level, we define as connected those locations in the sample that are closer to the backbone network than the median distance within the sample.[26] There are several reasons

[24] EXPLAIN

[25] Note that we use the quarter in which the survey was conducted to designate a given observation as pre- versus post- submarine cable arrival in all our outcome datasets as this is the time level at which Mahlknecht (2014)'s map of submarine cables reports arrival times in the various landing point cities along the coast.

[26] We calculate the distance between an individual or location in the sample and the nearest point on the country's backbone network. For DHS and Afrobarometer, we define the location of an individual as the GPS coordinates provided for his or her sampling cluster. For QLFS, we observe the location of the enumeration area to which the individual belongs (QLFS enumeration areas are small; there are more than 80,000 enumeration areas in South Africa). We thus define the location of the individual as the GPS coordinates of the centroid of his or her enumeration area. Similarly, for CIPC, we use the GPS coordinates of the centroid of the zip-code in question.

for this choice. First, dividing the sample into two groups facilitates easy inspection of pre-trends in the outcomes and possible differences in these across the two groups. Second, equal sized treatment and control groups help to maintain statistical power to detect the impact of fast Internet.[27] Finally, this approach simplifies interpretation of the estimates. There are of course other ways to define how wide an area around the backbone network we expect to benefit from the arrival of submarine Internet cables on the coast, but the median is a natural choice and in our main samples also corresponds roughly to the connectivity "reach" beyond a fiber-optic backbone network that experts believe to be technologically feasible (Commonwealth Telecommunications Organisation, 2012; Banerji & Chowdhury, 2013). Our empirical strategy likely underestimates the true effect of access to fast Internet in treated locations since locations further than the median distance away from the backbone network may have benefited from the arrival of submarine cables to a lesser extent.[28]

The identifying assumption is that locations close to and further away from the terrestrial backbone network were on parallel trends in employment outcomes prior to the arrival of submarine Internet cables in Africa, and did not experience systematically different idiosyncratic shocks after the submarine cables arrived. In Sub-section 5.3 we investigate possible violations of this assumption. We show that our results are robust to varying the radius around the backbone network used to define treatment status; to only including eventually-treated locations in the sample; and to controlling for location-specific linear and non-linear trends in the outcomes. We also show direct evidence of parallel pre-trends.

Figure II shows the submarine cables that had arrived in different landing point cities along the coast at various times during our data period, as well as the terrestrial backbone networks that submarine cables connect to. The map illustrates two important aspects of the identifying variation we exploit. First, submarine cables arrive throughout the period we consider, and at different points in time in different countries. This means that our difference-in-differences approach is "dynamic" in that we compare connected and unconnected locations across many different points in time rather than a single date (see e.g. Duflo, 2001). Second, the order in which different countries are reached by a given submarine cable is geographically determined. It is thus unlikely that arrival times across countries correlate with temporal variation in the difference between the employment trajectories of areas on and off the backbone network in those countries.

5 Results

5.1 How fast Internet infrastructure affects speed and take-up

Before analyzing how access to fast Internet affects job creation in Africa, we document that the arrival of submarine cables from Europe in fact increased speeds and use of the Internet. Column 1 of Table III shows results from running (1), except that the outcome variable is average Internet speed in a given location-quarter as measured in Akamai's speed data. We include location and quarter fixed effects. We find that submarine cable arrival increases measured speed in connected locations, relative to unconnected locations, by about 11 percent on average. Akamai informed us that because only a fraction of their speed tests are

[27] It is important to note that the sample-specific "treatment radius" will be greater in samples that are more sparsely distributed across space. For example, if the median distance to the backbone network in the multi-country DHS or Afrobarometer sample was used to define treatment in regressions using the South Africa QLFS dataset, then nearly the entire QLFS sample would be defined as "treated" after submarine cable arrival. This is because South Africa's backbone network is much more extensive and dense than those of poorer African countries in DHS and Afrobarometer.

[28] It is a priori of course also possible that more remote locations suffered from the increased access to faster Internet in treated locations. We investigate this possibility in Sub-section 5.3.

"sent" to servers on other continents, the estimated coefficient is likely much smaller than the true effect on speeds experienced by users.[29]

In the Afrobarometer surveys, respondents are explicitly asked if they use the Internet daily. In Column 2 of Table III we show results from again running (1), except that the outcome variable is a dummy for the individual reporting that he or she uses the Internet daily.[30] We find that submarine cable arrival increases daily Internet use in connected relative to unconnected locations by about 11 percent on average. There are likely two reasons why use of the Internet increases with submarine cable arrival. First, the product becomes more useful and desirable to potential users. Second, Kende & Rose (2015) report that the arrival of the submarine cables led to "drastic falls in prices for international capacity" (Kende & Rose, 2015, p. 15); a cost decrease that ISPs likely partly pass on to users via lower prices.

We conclude that both experienced speeds and use of the Internet increased considerably with the arrival of fast Internet infrastructure in Africa. These results highlight that effects on job creation may have arisen both through inframarginal users increasing and changing their use of the Internet, and through adoption by new users. In Section 6 we analyze the economic channels through which effects on job creation may have arisen in depth.

5.2 Effect of fast internet on overall job creation

Table IV shows the estimated effect of the arrival of fast Internet on job creation. In the nine countries for which we have DHS data – Benin, D.R. Congo, Ivory Coast, Liberia, Nigeria, Senegal, Sierra Leone, Tanzania, and Togo – we see a 1.2 percentage point, or 1.9 percent, increase in the probability that an individual has a job when fast Internet arrives. In the nine countries for which we have Afrobarometer data – Benin, Ghana, Kenya, Madagascar, Mozambique, Nigeria, Senegal, South Africa, and Tanzania – we see a similar 2.1 percentage point, or 3.7 percent, increase in the employment rate. In South Africa – the richest country in our sample, and for which we use labor force survey data – we see a 1.1 percentage point or 1.5 percent increase in employment. It thus appears that the arrival of fast Internet greatly increases job creation in African countries when fast Internet arrives.

5.3 Robustness

To probe the robustness of this paper's main findings, discussed in Section 5.2, we start by varying the radius around the backbone network used to define treatment status. In Table V we show how the results change with both minor and bigger increases and decreases in the "treatment radius". In almost all cases, the results remain highly significant and quantitatively very similar to those in Table IV. These findings are useful in part because they reduce any concerns we might have about potential violations of SUTVA, which could lead us to underestimate (if e.g. surveyed individuals commute to work in cities) or overestimate (if e.g. job creation in untreated areas suffers from fast Internet access in neighboring treated areas) the direct effect of fast Internet access.

[29] The reason is that Akamai's technology tries to send the signal from a user who is testing his or her Internet speed to the nearest server. In general, the signal is sent to a server in another country – typically in or via Europe – only in cases where Akamai does not own a server that is located within the user's ISP's own network. It is, however, speeds to other continents that are affected by the submarine cables, as discussed in Sub-section 2.1. Almost all Internet traffic from Africa does indeed travel to or via other continents, as also discussed in Sub-section 2.1. Despite significant efforts, we have not managed to find Internet speed data that explicitly measures speeds between specific locations in Africa and other continents over time.

[30] We take daily Internet use a reasonable proxy for work-related use.

In Table VI, we restrict attention to connected locations and thus estimate the effect of access to fast Internet in the sub-sample consisting only of eventually-treated individuals. In this case the comparison group for individuals in locations that get connected to a submarine cable at a given point in time consists of individuals in the same year but in countries that are not reached by a submarine cable at the same time because of the country-specific treatment dates. We thus prefer our baseline approach as outlined in Section 4 to the one used in Table VI, but it is nevertheless reassuring that the estimated effect of access to fast Internet on job creation, if anything, is bigger in magnitude and remains significant when only individuals in locations near the backbone networks are included in the sample.

In Table VII, we control, first, for grid-cell specific linear trends, and second, for non-linear trends specific to connected and unconnected locations respectively, i.e. interactions between the quarter dummies and connectedness status. It is only possible to implement these in the South Africa QLFS dataset, which is a balanced panel at the enumeration area×quarter level. Including these highly restrictive controls for location-specific trends have remarkably little effect on the magnitude and significance of the estimated effect of access to fast Internet on job creation.

Finally, in Figure III, we again take advantage of the balanced panel structure of the South Africa QLFS dataset to display the path of the employment rate in connected and unconnected areas before and after the arrival of the first submarine cable in South Africa. This allows us to inspect how the gap between the two areas evolves after fast Internet arrives, and, more importantly, to check if the identifying assumption of parallel pre-trends appears to hold.[31] Indeed, while the employment rate in both connected and unconnected areas declines between 2008 and 2011, in part due to the financial crisis that hit South Africa during that period, the shape of the graph is virtually identical for connected and unconnected areas before the submarine cable arrives in mid-2009. The gap in employment between the connected and unconnected areas starts to increase soon after submarine cable arrival and widens further over time, illustrating the treatment effect estimated in Table IV.

We conclude that the evidence suggests that the estimated effect of the arrival of fast Internet on job creation in Africa is robust and likely represents a causal response. We now investigate how employment rates in skilled and unskilled occupations were affected.

5.4 Effect of fast Internet on skilled and unskilled job creation

In the U.S., the "computerization" that has taken place since the 1970s has been shown to increase the relative demand for high-skill workers; decrease relative demand for middle-skill workers; and increase relative demand for low-skill workers (Acemoglu & Autor, 2011; Michaels *et al.* , 2014). Akerman *et al.* (2015) find similar consequences of the spread of broadband Internet in Norway. But in poor countries, the skill composition of the workforce, other interacting constraints, and the initial level of technological development differ. It is thus a priori unclear what the skill bias of fast Internet and associated consequences for skilled and unskilled job creation there are. The question is of particular importance in Africa where, as seen in Table II, skilled job creation has so far been limited, stunting incentives for human capital accumulation and rendering "steps" further up on global value-added ladders hard to access.

We explore this question in Table VIII using the DHS and South Africa QLFS datasets where occupations are labeled and can thus be categorized. In Benin, D.R. Congo, Ivory Coast, Liberia, Nigeria, Senegal,

[31] The reason why it is not possible to plot a similar graph for DHS and Afrobarometer is that, while all locations included in each sample appear at least twice during our data period, most grid-cells appear only two or three times. The sample would thus change from point to point on a hypothetical event-time X-axis. In contrast, each enumeration area in the South Africa QLFS dataset is surveyed every quarter so that the sample is balanced across the X-axis.

Sierra Leone, Tanzania, and Togo, the arrival of fast Internet significantly increased the probability that an individual holds a professional or a sales job, by 10 and eight percent respectively. There is also a 46 pecent increase in domestic employment (off of a small base), though this estimate is only marginally significant. The probability of holding a clerical job decreased, while there was no significant change in the employment rate in services. Similarly, in South Africa the probability of holding a professional job increased by nine percent, and the employment rate in "elementary" work decreased. Unlike in the DHS sample, employment in services increased in South Africa, by four percent.

While the literature on rich countries has focused more on wage levels than job creation, our findings thus imply a skill bias of fast Internet in Africa that is quite similar to what has been found for recent technological advances in the U.S. and Europe.[32] The magnitude of the increase in skilled job creation is particularly noteworthy and suggests that fast Internet enables the creation of "good" jobs even in places where unskilled work was the norm a priori.

6 Mechanisms

6.1 Employment effects mediated by changes in speed and take-up after the arrival of fast Internet infrastructure

As we saw in Sub-section 5.1, the arrival of submarine cables on the coast significantly increased both average speed and daily use of the Internet in connected relative to unconnected locations in Africa. Since the effects on job creation may thus arise both through inframarginal users increasing and changing their use of the Internet, and through adoption by new users, the exclusion restriction is violated in regressions in which we instrument for either average speed or daily use of the Internet with the treatment as defined above. It is nevertheless informative to report such results so that we can get a sense of the implied magnitudes.[33]

We start by instrumenting for average Internet speed in the relevant location with the treatment. When we use the sub-samples that consist only of observations from location×quarters that appear in both the relevant outcome sample (DHS, Afrobarometer, or QLFS) and Akamai's Internet speed data, we are heavily under-powered, as can be seen in the "F stat, reduced sample" row in Table IX.[34] We thus follow Angrist & Krueger (1992)'s two-sample 2SLS approach and use *all* available locations for both the the first stage (the ∼900 locations in Africa that appear in Akamai's Internet speed data), and the second stage (all locations that appear in the relevant outcome sample). This approach yields an F statistic of 18.85 in the first stage so that we avoid weak instrument challenges. We report Pacini & Windmeijer (2016)'s extension of Murphy-Topel standard errors to the two-sample 2SLS setting since these allow for heteroskedasticity.

If taken at face value, the coefficients in Table IX suggest that the increase in average Internet speed in connected locations after the arrival of submarine cables imply an increase in the probability of employment of 4.88 percent in the DHS sample, 1.66 percent in the Afrobarometer sample, and 0.52 percent in the QLFS sample, given the first stage coefficient estimated in Table III. We should not take these estimates literally, however, both because the first stage response is likely underestimated due to limitations of the speed data (implying that the second stage relationship would be overestimated), and because some of the employment response is likely due to increased use of the Internet rather than the increase in speed. It is nonetheless

[32] An exception is that we find a decrease in employment in a "lowest-skill" occupation category in South Africa.

[33] See e.g. Malamud & Pop-Eleches (2011) for a similar approach.

[34] One possible reason is that Akamai provided us with average speed data only for ∼900 locations in Africa. (We thus associate the speed for a given "city" with any location in the relevant outcome sample that falls within a 20 kilometer radius of that city.) Another is the limitations of Akamai's speed data for our purposes discussed in Sub-section 5.1.

reassuring that instrumenting for Internet speed with the arrival of the submarine cables yields coefficients that fall within a plausible range.

[TBA: INSTRUMENTING FOR DAILY INTERNET USE]

We next investigate the economic mechanisms that translate an increase in Internet speed and use of the Internet into increased job creation.

6.2 Firm creation and business ownership

To explore how the arrival of fast Internet affected firm creation and business ownership, we first use South Africa's CIPC dataset, which records registered firms by zip code, date, and firm type.[35] As seen in Table X, the estimated effect on overall firm creation is small and insignificant, as is the effect on new manufacturing firms. We do, however, find a significant 14 percent increase in new technological firms each quarter after submarine cable arrival.[36] It appears plausible that these new technological firms contributed to the increased rate of skilled job creation in South Africa after the arrival of fast Internet.

Table X also shows the effect of fast Internet arrival on business ownership in South Africa, which is recorded in the QLFS dataset. We find a marginally significant 3 percent increase in business ownership. There are two possible ways to reconcile this finding with the fact that we do not observe an increase in overall firm creation. First, ownership of the existing stock of firms may have become more widely dispersed across individuals. To the extent that access to fast Internet enables a broader set of individuals to profitably run a firm, this explanation is plausible. If so, the widening of business ownership after the arrival of fast Internet likely contributed to increased job creation in part by generating jobs for the new owners themselves. But it may also be that South African individuals, when asked in QLFS if they own a business, answer the question not only with formal, registered firms in mind, but also informal firms. If so, the arrival of fast Internet may have increased job creation by increasing informal firm births.

6.3 Use of the Internet in existing firms

We now investigate if the arrival of fast Internet affected employment in existing firms, and, if so, why. For this purpose we use Ethiopia's LMMIS dataset of medium and large manufacturing firms, which is essentially the only yearly firm panel dataset with close to universal coverage and detailed information on output and inputs available that exists across all of Africa. In Table XI, we first show, using the same identification approach as throughout this paper, that the arrival of fast Internet led to a 19 log point increase in the number of workers per firm in connected relative to unconnected locations in Ethiopia. It thus appears that the increased job creation due to availability of fast Internet observed continent-wide occurs also in Ethiopia, though to a much greater extent. [IN ONGOING WORK WE ARE USING THE FULL LMMIS DATA TO STRUCTURALLY ESTIMATE THE PRODUCTION FUNCTIONS OF ETHIOPIAN MANUFACTURING FIRMS. WE'RE INTERESTED IN HOW THE MARGINAL OUTPUT RETURN TO AN ADDITIONAL WORKER OF DIFFERENT TYPES CHANGES WITH PROXIES FOR USE OF THE INTERNET, AND ORGANIZATIONAL CHANGES MADE WHEN FAST INTERNET BECAME AVAILABLE]

[35] As discussed in Section 3, we coded up firm type from the establishments' names.

[36] GIVE EXAMPLES OF TYPES OF TECH FIRMS.

7 Conclusion

[TO BE ADDED]

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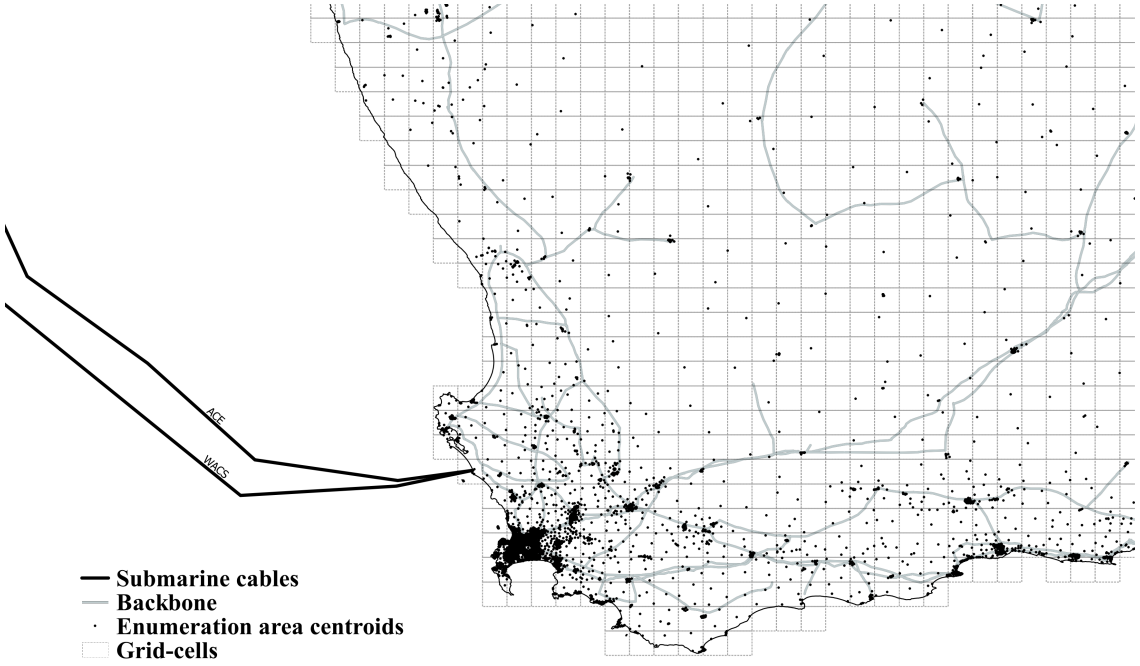
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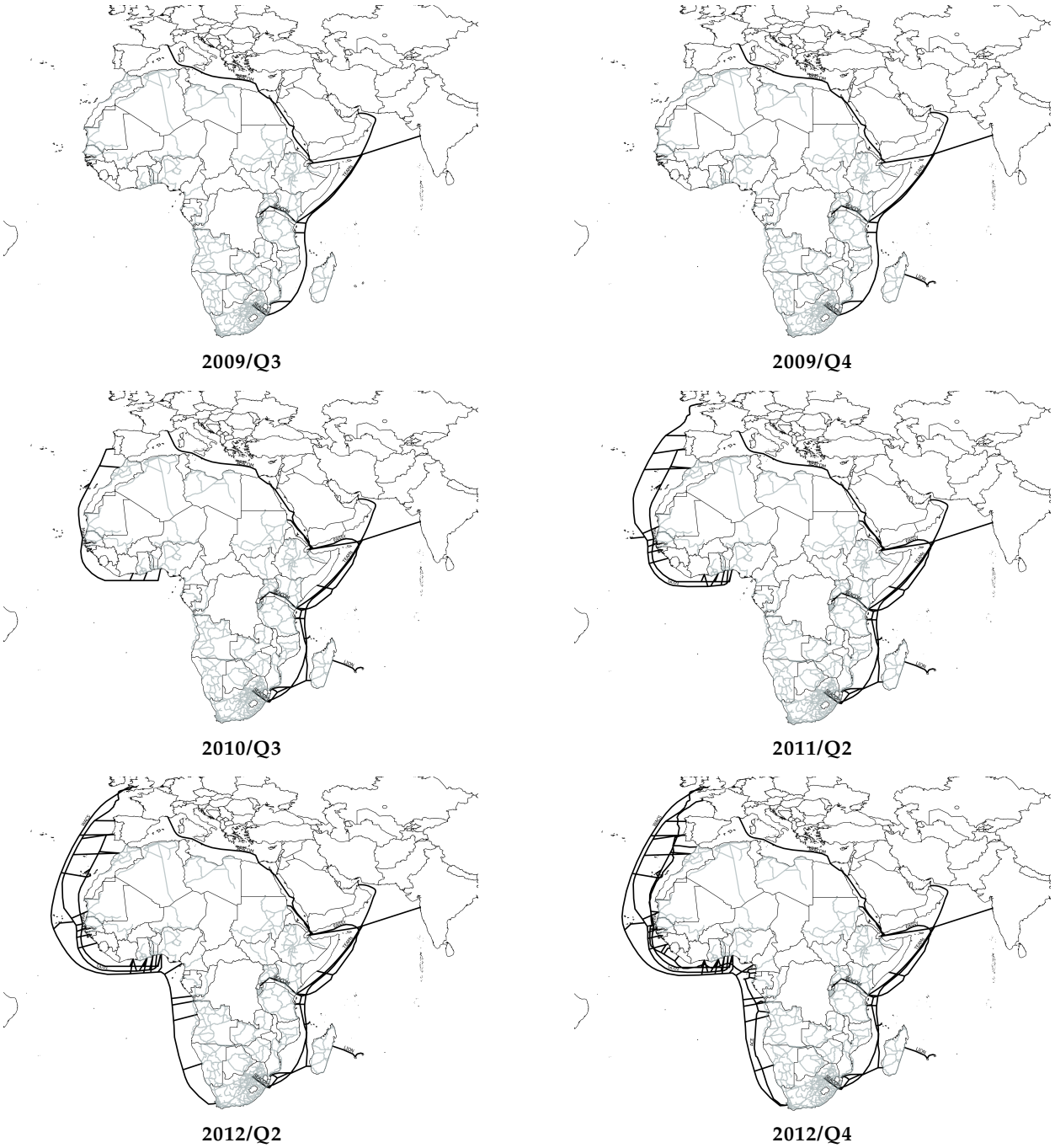
Figures

FIGURE I: THE BACKBONE NETWORK, GRID-CELLS USED FOR FIXED EFFECTS, AND SAMPLING CLUSTERS (SOUTH AFRICA QLFS AS EXAMPLE)



This figure shows two submarine cables arriving to Yzerfontein, just north of Cape Town in South Africa, and the country's terrestrial network. With the Afrobarometer and DHS, we know the individuals' exact location. With the South African Quarterly Labour Force Survey we know which enumeration area (EA) each individual lives in. We therefore calculate the centroid of each EA (the black dots shown on the map) and calculate the closest distance between the centroids and the terrestrial network. Individuals living within the median distance (about 3 km) are said to be treated by submarine-cable arrival as they arrive. As with the other samples, we include grid-cell fixed effects in all estimations. The grid is 0.2 x 0.2 decimal degrees (about 20 x 20 km).

FIGURE II: SUBMARINE-CABLE ARRIVAL IN AFRICA



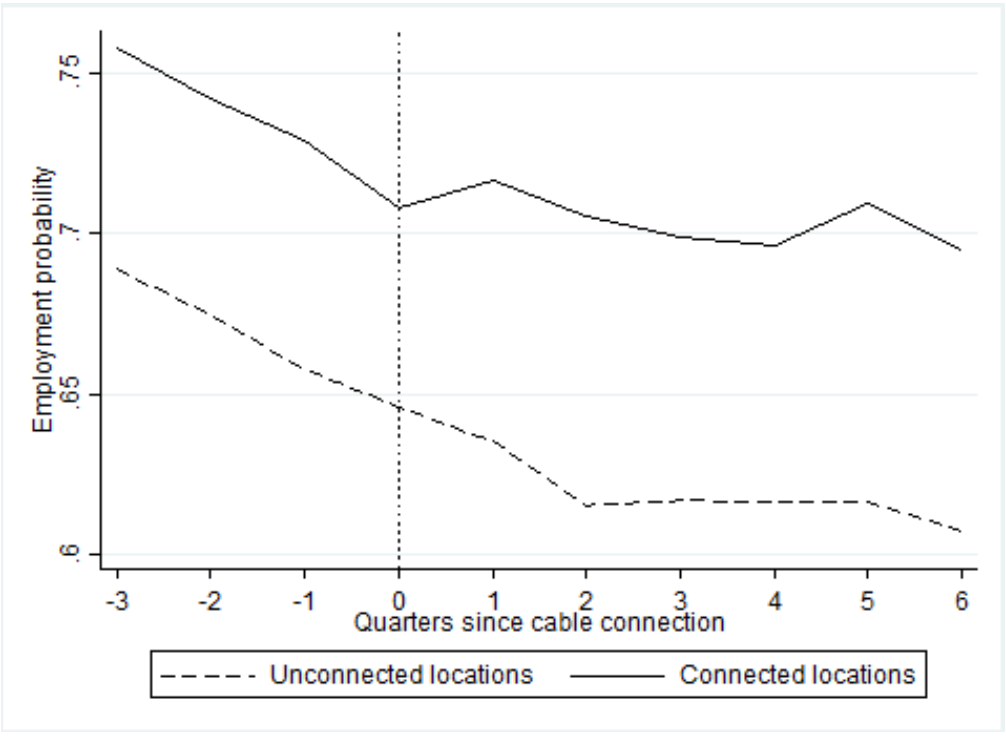
2009/Q3 **2009/Q4**

2010/Q3 **2011/Q2**

2012/Q2 **2012/Q4**

This graph shows the arrival of submarine cables over time. The first two cables in our sample period arrived in 2009/Q3 and the last in 2012/Q4. Landing points are usually close to a major coastal city, such as Mombasa in Kenya or Cape Town in South Africa. The submarine cables are Seacom and Teams (2009/Q3), Lion (2009/Q4), Eassy and MainOne (2010/Q3), Glo1 (2011/Q2), WACS (2012/Q2) and ACE (2012/Q4).

FIGURE III: EMPLOYMENT RATE IN CONNECTED AND UNCONNECTED LOCATIONS BEFORE AND AFTER FAST INTERNET ARRIVAL



This graph plots the employment rate in locations in South Africa close to versus further away from the backbone network before and after the first submarine cable in our data period arrived in the country (2009/Q3).

Tables

TABLE I: INTERNET SPEEDS AND USAGE RATES BEFORE FAST INTERNET ARRIVAL, BY COUNTRY

Unit of analysis:	Speed (KB/sec)		Usage
	Location		Individual
	Mean	SD	(0/1)
Benin	5.45	0.55	0.14
Treated	5.44	0.57	0.22
Not Treated	5.48	0.43	0.02
D.R. Congo	5.45	0.77	
Treated	5.45	0.17	
Not Treated	5.45	0.79	
Ivory Coast	5.74	0.72	
Not Treated	5.74	0.72	
Ghana	5.53	0.73	0.13
Treated	5.79	0.64	0.19
Not Treated	5.33	0.74	0.06
Kenya	5.12	0.60	0.23
Treated	5.12	0.60	0.26
Not Treated			0.16
Liberia	5.93	0.66	
Treated	6.05	0.49	
Not Treated	5.91	0.70	
Madagascar	5.33	0.23	0.08
Treated	5.33	0.23	0.09
Not Treated			0.04
Mozambique	5.37	0.55	0.09
Treated	5.56	0.16	0.09
Not Treated	5.31	0.62	0.07
Nigeria	5.73	0.92	0.40
Treated	5.82	0.78	0.48
Not Treated	5.70	0.97	0.31
Sierra Leone	5.81	0.38	
Treated	5.92	0.43	
Not Treated	5.63	0.20	
Senegal	6.14	0.51	0.17
Treated	6.26	0.21	0.21
Not Treated	5.77	0.90	0.10
Togo	5.28	0.16	
Treated	5.28	0.16	
Tanzania	5.14	0.59	0.08
Treated	5.11	0.65	0.08
Not Treated	5.20	0.39	0.07
South Africa	6.52	1.16	0.34
Treated	6.38	1.10	0.36
Not Treated	6.99	1.21	0.24

Internet speed data from Akamai. Internet usage rates from Afrobarometer. Treatment = $\text{SubmarineCables}_{\mathbf{j}(i)t}$. Individuals (locations) are considered connected (i.e., have $\text{SubmarineCables}_{\mathbf{j}(i)t} > 0$ after submarine cable arrival in the relevant country) if they are closer than the median individual (location) in the relevant sample to the backbone networks (∼6 kilometers for Akamai; ∼3 kilometers for Afrobarometer).

TABLE II: EMPLOYMENT RATES BEFORE FAST INTERNET ARRIVAL, BY COUNTRY AND SKILL LEVEL

Unit of analysis	Employed (0/1)	Employed, Skilled (0/1)	Employed, Unskilled (0/1)
Benin	0.82	0.09	0.73
Treated	0.81	0.10	0.72
Not Treated	0.86	0.07	0.79
D.R. Congo	0.53	0.06	0.48
Treated	0.46	0.07	0.39
Not Treated	0.57	0.05	0.52
Ivory Coast	0.63	0.06	0.58
Treated	0.58	0.08	0.50
Not Treated	0.65	0.05	0.60
Ghana	0.66		
Treated	0.69		
Not Treated	0.63		
Kenya	0.51		
Treated	0.52		
Not Treated	0.48		
Liberia	0.55	0.03	0.52
Treated	0.48	0.03	0.45
Not Treated	0.60	0.02	0.58
Madagascar	0.77		
Treated	0.77		
Not Treated	0.77		
Mozambique	0.28		
Treated	0.28		
Not Treated	0.29		
Nigeria	0.60	0.15	0.45
Treated	0.61	0.17	0.45
Not Treated	0.58	0.13	0.46
Sierra Leone	0.70	0.07	0.63
Treated	0.59	0.15	0.45
Not Treated	0.72	0.05	0.67
Senegal	0.39	0.06	0.32
Treated	0.39	0.07	0.33
Not Treated	0.37	0.05	0.32
Togo	0.75	0.19	0.56
Treated	0.75	0.19	0.57
Not Treated	0.75	0.23	0.52
Tanzania	0.72	0.13	0.60
Treated	0.74	0.11	0.62
Not Treated	0.71	0.14	0.57
South Africa	0.71	0.15	0.26
Treated	0.73	0.17	0.28
Not Treated	0.63	0.09	0.20

Data from Demographic Health Survey (DHS), Afrobarometer, and South African Quarterly Labor Force Surveys. Employment defined as skilled if respondent indicates a professional, technical, or manual skilled occupation; all other occupations defined as unskilled. Rows are left blank where no direct data on occupation is available. Treatment = $\text{SubmarineCables}_{j(i)t}$. Individuals are considered connected (i.e., have $\text{SubmarineCables}_{j(i)t} > 0$ after submarine cable arrival in the relevant country) if they are closer than the median individual in the relevant sample to the backbone networks ($\sim$39 kilometers for DHS; $\sim$3 kilometers for Afrobarometer).

TABLE III: EFFECT OF SUBMARINE CABLE ARRIVAL ON INTERNET SPEED AND USAGE

	First stage	Take up
	Speed	Usage
Unit of analysis:	City (Log KB/second)	Individual (0/1)
Treatment	0.109***	0.0124**
	(0.0251)	(0.00548)
Mean of outcome	6.499	0.114
Time FE	Yes	Yes
City FE	Yes	Yes
Observations	8,809	9,543

OLS estimates. Quarterly internet speed data from Akamai, 2007Q3-2014Q1. Annual internet usage data from Afrobarometer, 2008-2013. Internet speed is defined in logs. Use is equal to one if an individual states that she uses the Internet every day in the Afrobarometer. Villages in the Afrobarometer surveys are matched to cities with information on Internet speed in Akamai through a 20 km radius. Robust standard errors clustered at the city level in parentheses. Cities and individuals assumed to be treated if they reside within the median distance ($\sim$18 kilometers for Akamai; $\sim$3 kilometers for Afrobarometer) of a terrestrial cable network connected to high-speed Internet. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE IV: EFFECT OF FAST INTERNET ON EMPLOYMENT

	DHS	Afrobarometer	SA-QLFS
Unit of analysis:	Individual (0/1)	Individual (0/1)	Individual (0/1)
Treatment	0.0119***	0.0213***	0.0108***
	(0.00454)	(0.00645)	(0.00403)
Mean of outcome	0.620	0.579	0.711
Time FE	Yes	Yes	Yes
Grid-cell FE	Yes	Yes	Yes
Observations	152,674	12,683	783,154

OLS regressions. Robust standard errors clustered at the grid-cell level in parentheses. Mean of outcome computed using control and treatment groups prior to treatment. The Demographic and Health Survey (DHS) sample includes Benin, D.R. Congo, Ivory Coast, Liberia, Nigeria, Senegal, Sierra Leone, Tanzania and Togo, and covers 1998–2013. The Afrobarometer sample includes Benin, Ghana, Kenya, Madagascar, Mozambique, Nigeria, Senegal, South Africa and Tanzania, and covers 2008–2013. The South Africa data Quarterly Labor Force Survey (QLFS) sample covers 2008–2014. Treatment = $\text{SubmarineCables}_{\text{j}(i)t}$. Individuals are considered connected (i.e., have $\text{SubmarineCables}_{\text{j}(i)t} > 0$ after submarine cable arrival in the relevant country) if they are closer than the median individual in the relevant sample to the backbone networks ($\sim$39 kilometers for DHS; $\sim$3 kilometers for Afrobarometer and QLFS).
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE V: EFFECT OF FAST INTERNET ON EMPLOYMENT, VARYING TREATMENT RADIUS

	DHS	Afrobarometer	SA-QLFS
Unit of analysis:	Individual (0/1)	Individual (0/1)	Individual (0/1)
Treatment radius: baseline x .5	0.00392	0.0220***	0.0105**
	(0.00436)	(0.00783)	(0.00444)
Treatment radius: baseline x .7	0.00696	0.0200***	0.00974**
	(0.00450)	(0.00674)	(0.00418)
Treatment radius: baseline x .9	0.00991**	0.0224***	0.0118***
	(0.00452)	(0.00666)	(0.00380)
Treatment radius: baseline x .95	0.0117**	0.0220***	0.0125***
	(0.00454)	(0.00647)	(0.00392)
Treatment radius: baseline x .97	0.0115**	0.0219***	0.0116***
	(0.00454)	(0.00643)	(0.00403)
Treatment radius: baseline x .99	0.0117**	0.0216***	0.0116***
	(0.00453)	(0.00643)	(0.00405)
Baseline treatment radius (median)	0.0119***	0.0213***	0.0108***
	(0.00454)	(0.00645)	(0.00403)
Treatment radius: baseline x 1.01	0.0115**	0.0190***	0.0104***
	(0.00457)	(0.00667)	(0.00398)
Treatment radius: baseline x 1.03	0.0119***	0.0189***	0.0102**
	(0.00456)	(0.00663)	(0.00408)
Treatment radius: baseline x 1.05	0.0120***	0.0205***	0.0101***
	(0.00456)	(0.00660)	(0.00391)
Treatment radius: baseline x 1.1	0.0126***	0.0187***	0.0109***
	(0.00467)	(0.00665)	(0.00401)
Treatment radius: baseline x 1.3	0.0137***	0.0193***	0.00977**
	(0.00484)	(0.00684)	(0.00447)
Treatment radius: baseline x 1.5	0.0147***	0.0158**	0.00844
	(0.00489)	(0.00684)	(0.00517)
Mean of outcome	0.620	0.579	0.711
Time FE	Yes	Yes	Yes
Grid-cell FE	Yes	Yes	Yes
Observations	152,674	12,683	783,154

OLS regressions. Robust standard errors clustered at the grid-cell level in parentheses. Mean of outcome computed using control and treatment groups prior to treatment. The Demographic and Health Survey (DHS) sample includes Benin, D.R. Congo, Ivory Coast, Liberia, Nigeria, Senegal, Sierra Leone, Tanzania and Togo, and covers 1998–2013. The Afrobarometer sample includes Benin, Ghana, Kenya, Madagascar, Mozambique, Nigeria, Senegal, South Africa and Tanzania, and covers 2008–2013. The South Africa data Quarterly Labor Force Survey (QLFS) sample covers 2008–2014. Treatment = $\text{SubmarineCables}_{\mathbf{j}(i)t}$. Individuals are considered connected (i.e., have $\text{SubmarineCables}_{\mathbf{j}(i)t} > 0$ after submarine cable arrival in the relevant country) if they are closer than the median individual in the relevant sample to the backbone networks ($\sim$39 kilometers for DHS; $\sim$3 kilometers for Afrobarometer and QLFS).
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE VI: EFFECTS ON EMPLOYMENT WHEN ONLY INCLUDING EVENTUALLY TREATED OBSERVATIONS

	DHS	Afrobarometer
Unit of analysis:	Individual (0/1)	Individual (0/1)
Treatment	0.0298*	0.0386**
	(0.0157)	(0.0189)
Mean of outcome	0.644	0.583
Time FE	Yes	Yes
Grid-cell FE	Yes	Yes
Observations	75,177	6,249

OLS regressions. Robust standard errors clustered at the grid-cell level in parentheses. Mean of outcome computed using control and treatment groups prior to treatment. This table shows the main results on employment probability, with the exception that we drop all grid-cells that are never treated. These grid-cells are situated outside the median distance to the national backbone. The Demographic and Health Survey (DHS) sample includes Benin, D.R. Congo, Ivory Coast, Liberia, Nigeria, Senegal, Sierra Leone, Tanzania and Togo, and covers 1998–2013. The Afrobarometer sample includes Benin, Ghana, Kenya, Madagascar, Mozambique, Nigeria, Senegal, South Africa and Tanzania, and covers 2008–2013. Treatment = $\text{SubmarineCables}_{j(i)t}$. Individuals are considered connected (i.e., have $\text{SubmarineCables}_{j(i)t} > 0$ after submarine cable arrival in the relevant country) if they are closer than the median individual in the relevant sample to the backbone networks ($\sim$39 kilometers for DHS; $\sim$3 kilometers for Afrobarometer).
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE VII: INCLUDING TRENDS

	SA-QLFS	
	Employment probability	
Unit of analysis:	Individual (0/1)	Individual (0/1)
Treatment	0.0121***	0.0103**
	(0.00451)	(0.00431)
Mean of outcome	0.675	0.675
Time FE	Yes	Yes
Grid-cell FE	Yes	Yes
Linear grid-cell trend	Yes	No
Connected status $\times$ Quarter	No	Yes
Observations	783,154	783,154

OLS regressions. Robust standard errors clustered at the location-cell level in parentheses. Linear city trends and linear grid-cell trends interact each city/grid-cell dummy with the time variable. Connected status $\times$ Quarter interacts whether or not a city/grid-cell is eventually treated with the time variable.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE VIII: EFFECT OF FAST INTERNET ON EMPLOYMENT, BY OCCUPATION

Panel A: Benin, D.R. Congo, Ivory Coast, Liberia, Nigeria, Senegal, Sierra Leone, Tanzania and Togo (DHS)						
Unit of analysis:	Professional (0/1)	Clerical (0/1)	Services (0/1)	Domestic (0/1)	Sales (0/1)	
Treatment	0.00396**	-0.00167***	0.00221	0.000828*	0.0203***	
	(0.00159)	(0.000619)	(0.00299)	(0.000476)	(0.00558)	
Mean of outcome	0.0382	0.00774	0.0593	0.00180	0.245	
Time FE	Yes	Yes	Yes	Yes	Yes	
Grid-cell FE	Yes	Yes	Yes	Yes	Yes	
Observations	152,881	152,881	152,881	152,881	152,881	
Panel B: South Africa (QLFS)						
Unit of analysis:	Professional (0/1)	Clerical (0/1)	Services (0/1)	Domestic (0/1)	Technical (0/1)	Elementary Work (0/1)
Treatment	0.00341**	0.00120	0.00354**	-0.000842	0.00236	-0.00422**
	(0.00160)	(0.00176)	(0.00138)	(0.00167)	(0.00194)	(0.00215)
Mean of outcome	0.0363	0.0743	0.0915	0.0577	0.0792	0.164
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Grid-cell FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	783,154	783,154	783,154	783,154	783,154	783,154

OLS estimates. Robust standard errors clustered at the grid-level in parentheses. Data from Demographic and Health Surveys (DHS) and South Africa Quarterly Labor Force Surveys. includes unskilled occupations such as sanitation and maintenance. Individuals assumed to be treated if they reside within the median distance (39 kilometers for DHS, or 3 kilometers for QLFS) of a backbone network connected to high-speed Internet.

TABLE IX: TWO-SAMPLE 2SLS RESULTS

	DHS	Afrobarometer	SA-QLFS
Unit of analysis, 1st stage:	City (Log KB/second)	City (Log KB/second)	City (Log KB/second)
Unit of analysis, 2S2SLS:	Individual (0/1)	Individual (0/1)	Individual (0/1)
Treatment	0.4778***	0.1519***	0.0475***
	(0.0941)	(0.0339)	(0.01059)
Mean of Outcome	0.650	0.578	0.725
Time FE	Yes	Yes	Yes
City FE	Yes	Yes	Yes
F stat, full sample	18.85	18.85	18.85
F stat, reduced sample	1.17	2.05	0.05
Observations	33,440	10,350	563,259

OLS regressions. Robust standard errors clustered at the city level in parentheses. Estimates from a two-sample 2SLS approach is shown in this table. The first stage regression is estimated with all available data from Akamai (F stat is 18.85). The two-sample 2SLS estimates come from dividing the reduced form results using observations in the Afrobarometer, DHS and SA QLFS that lie within a 20 km radius from an Akamai city, by the first stage results. Standard errors are corrected using Pacini and Windmeijer (2016). The first stage estimates using only Akamai cities that map to the surveyed villages (by a 20 km radius) are considerably weaker. The F stats for these regressions are also shown. .
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE X: ESTIMATED EFFECT OF FAST INTERNET ON FIRM CREATION AND BUSINESS OWNERSHIP IN SOUTH AFRICA

	CIPC			QLFS
Unit of analysis:	**All Firms** Firm (Log #)	**Technology** Firm (Log #)	**Manufacturing** Firm (Log #)	**Own Business** Individual (0/1)
Treatment	0.0119	0.0389**	0.00653	0.00164*
	(0.0367)	(0.0197)	(0.0115)	(0.000989)
Mean of outcome	2.045	0.289	0.0967	0.0598
Time FE	Yes	Yes	Yes	Yes
Grid-cell FE	Yes	Yes	Yes	Yes

OLS estimates. Robust standard errors clustered at the grid-cell level in parentheses. Quarterly data from Companies and Intellectural Property Commission (CIPC) 2007Q1-2014Q4, and South Africa Quarterly Labor Force Surveys (QLFS) 2008-2014. All firms is the log of all newly registered firms in a quarter. Technology is the log number of newly registered tech firms, such as engineering firms or sellers of technical equipment. Manufacturing is the log number of newly registered manufacturing firms. Individuals and firms assumed to be treated if they reside within the mediance distance (2 kilometers for CIPC, or 3 kilometers for QLFS) from a terrestrial cable network connected to high-speed Internet.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE XI: EFFECT OF FAST INTERNET ON ETHIOPIAN FIRMS

	Employees (log)
Unit of analysis:	Firm (Log #)
Treatment	0.193***
	(0.0609)
Mean of outcome	3.968
Time FE	Yes
Firm FE	Yes
Observations	17,503

OLS regressions. Robust standard errors clustered at the grid-cell level in parentheses. Employees are the number of employees in each firm in logs. Treatment = SubmarineCables$_{\mathbf{j}(i)t}$. Individuals are considered connected (i.e., have SubmarineCables$_{\mathbf{j}(i)t} > 0$ after submarine cable arrival) if they are closer than the median firm to the backbone networks ($\sim$1 kilometers).
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$