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

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Abstract

This paper provides evidence on how the expansion of fast Internet along its current frontier in developing countries affects job creation. 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 four datasets covering 14 countries show large positive effects on employment rates. A decrease in unskilled jobs is offset by a bigger increase in jobs in higher-skill occupations, and outside of South Africa job inequality between more and less educated workers falls. We use detailed firm level data available for some countries to investigate how higher average speeds for existing users and higher take-up enable greater (skilled) job creation. We find an increase in (i) workers and skilled positions per firm, firm level productivity, and the productivity of workers in skilled positions in existing Ethiopian manufacturing firms, (ii) firm entry in South Africa in the sectors that hire workers in the occupations that see growth when fast Internet becomes available, and (iii) workers in skilled positions, exports, and use of websites among firms in seven countries. Finally, we show that the impact on job creation is accompanied by a rise in average incomes. Our findings shed light on how modern information and communications technology affects total job creation, structural change, job inequality, and firm growth in the poorest region of the world.

JEL codes: D2, J2, O1, O3

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1 Introduction

The slow economic progress of poor workers in developing countries during the last few decades surprised economists. Traditional trade models predict the rising inequality seen in rich countries during this period of integration in the global economy, but they predict the opposite in poor countries. Two potential explanations were proposed and compared: skill-biased technological change (SBTC) and features of international trade – such as outsourcing (see e.g. Feenstra & Hanson, 1996, 1999, 2003) and quality upgrading (see e.g. Verhoogen, 2008; Frías *et al.* , 2009) – that could alter the logic underlying expectations of job growth and greater equality in unskilled labor-abundant poor countries post-integration (Feenstra & Hanson, 2003; Goldberg & Pavcnik, 2007; Harrison *et al.* , 2011; Goldberg, 2015). Two decades of intense research and debate led to wide agreement that both explanations play a role, and that they probably interact (Wood, 1995; Acemoglu, 2003; Attanasio *et al.* , 2004; Koren & Csillag, 2016). But this preliminary conclusion was built on studies of *trade-induced* technological change: to date, there is no direct evidence on the average and distributional economic effects in poor countries of the forms of modern information and communication technologies (ICT) found to help explain the increasing inequality in rich countries' labor markets.

In this paper we attempt to provide the first estimates of how fast Internet – "the greatest invention of our time" (The Economist, 2012) – affects poor countries' economies.[1] 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 and capacity on the terrestrial network. We show how overall employment rates, occupational employment shares, job inequality across the educational attainment range, and the underlying extensive (Internet take-up) and intensive (Internet speed) margin, respond. We also show evidence on three particular mechanisms through which take-up and speed affect job creation: changes in firm entry across sectors; changes in productivity in existing firms; and changes in exporting. Finally, we show how average incomes in the locations that see changes in job creation patterns with the arrival of fast Internet respond.

It has been difficult to study SBTC directly because, other than in local experiments, ICT technologies are not randomly allocated, but introduced where economic benefits are expected. While this is true everywhere, developing countries additionally tend to lack systematic and detailed labor market and firm level datasets, especially in the poorest regions of the world where the economic environment differs the most from the West (see Katz & Autor (1999); Bond & Van Reenen (2007); Goldin & Katz (2007) for overviews of the SBTC literature on rich countries). We overcome the first obstacle by interacting time variation generated by the gradual arrival of submarine Internet cables from Europe in landing point cities on Africa's coast between 2006 and 2014 with cross-sectional variation in whether a given location is covered by the terrestrial "backbone" network that starts at the landing point cities.[2] 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 economic outcomes for locations on versus off the backbone network. The collection of 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 representative household surveys (panels at location level) from 14 African countries with a combined population of roughly half a billion people with firm level datasets (also panels at location level) from Ethiopia, South Africa, and a group of

[1] See World Bank (2016) for an overview of the existing correlational evidence, and more details below.

[2] During this period, each coastal country effectively had its own separate backbone network, as explained in Section 2.

seven African countries.[3] We use the firm level data to show evidence on three especially important mechanisms – firm entry, productivity, and exporting – through which fast Internet may affect job creation.[4] We also use data on speed and take-up of the Internet to tie the reduced form estimates to the intensive and extensive margin of use. Finally, we use individual level data from South Africa and data on night lights from satellite images covering all 14 countries to study how fast Internet ultimately affects average incomes (see Henderson *et al.* , 2012; Bleakley & Lin, 2012; Michalopoulos & Papaioannou, 2013; Lowe, 2014b).

Our approach differs from much of the related literature in that we make employment status rather than wages (among the employed) our primary outcome. This is partly for data availability reasons, but it is also a sensible choice in a developing region context.[5] "Job inequality" captures poverty, learning, and income inequality that is due to (i) employment– a component of first order importance in Africa that focusing on wage inequality would miss (see e.g. Magruder, 2012; Hardy & McCasland, 2015) – and (ii) having a "good" job (here: skilled position) versus a less good job (here: unskilled position) (see also Davis & Harrigan, 2011; Card *et al.* , 2013, 2015; Koren & Csillag, 2016). Finally, changes in the probability of a worker being employed in a position belonging to a given type of occupation are informative not only of demand for qualified workers, but also of trends in "structural change" in developing economies.

Our three main sets of results are as follows. First, we find that the probability that an individual is employed increases by 1.9 and 4 percent respectively in the two groups of countries covered by our household survey datasets, and by 1.9-2.3 percent in South Africa, when fast Internet becomes available. While employment responses of such magnitudes indicate that building fast Internet infrastructure may be among the currently known 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.

Second, we find that the probability of being employed in a position belonging to a skilled occupation increases, and the probability of having an unskilled job decreases, when fast Internet becomes available. These two broad categories defined by the International Labour Organization (ISCO level 2-4 versus 1) can be further broken down into the four underlying occupational skill levels. In both South Africa and the nine poorer African countries covered by a household survey that records occupation information, employment in "highly skilled" (ISCO level 4) and "moderately skilled" (ISCO level 2) occupations increases and employment in unskilled occupations (ISCO level 1) decreases. In South Africa there is also an increase in employment in "skilled" occupations (ISCO level 3).

Third, inequality in employment outcomes across the educational attainment range falls when fast Internet arrives in Africa. The probability of having a skilled job increases and the probability of having an unskilled job decreases for all levels of educational attainment, but there is a significant increase in the "any employment" rate only for those with completed primary school or less. In South Africa it is those with secondary school who see the biggest increase in "any" and skilled employment.

[3]One household survey (Afrobarometer) covers Benin, D.R. Congo, Ivory Coast, Liberia, Nigeria, Senegal, Sierra Leone, Tanzania, and Togo; and the other (DHS) Benin, Ghana, Kenya, Madagascar, Mozambique, Nigeria, Senegal, South Africa, and Tanzania. (We follow Young (2012) and McMillan & Harttgen (2014) in using DHS surveys to study the evolution of African economies). We refer to these 14 countries jointly as "Africa" for simplicity. We also use two labor force surveys from South Africa.

[4]We study a large sample from the world's poorest countries and a transformative technology that likely affects "ultimate" economic outcomes through many different channels. This means that data limitations prevent us from investigating *all* channels through which fast Internet may operate, or determining what *share* of the changes in employment patterns firm entry, productivity, and exporting account for. The literature on information frictions in developing countries hints at additional mechanisms that may also play a role (Bloom *et al.* , 2007; Antrás & Garicano, 2008; Magruder, 2010; Beaman & Magruder, 2012; Allen, 2014; Eaton *et al.* , 2015; Hardy & McCasland, 2015; Atkin *et al.* , 2016; Mitra *et al.* , 2016); we leave investigation of these possibilities for future research.

[5]While inequality is closely tied to unemployment also in advanced countries (see e.g. Galbraith, 2008), it has been natural for studies of tight(er) labor markets to focus primarily on wages. Results for employment shares are often presented as well.

To compare these results to the existing evidence on recent SBTC in developed countries, we must distinguish between the skill level of *jobs* and *workers*. Our findings suggest that fast Internet in Africa affects employers' relative demand for skilled and unskilled positions similarly to "computerization" and broadband Internet in rich countries (Autor *et al.* , 1998, 2003, 2008; Goos *et al.* , 2014; Katz & Margo, 2014; Akerman *et al.* , 2015), although the increase in skilled job creation is of greater magnitude in Africa. In contrast, while ICT tends to increase inequality across the educational attainment range in rich countries,[6] fast Internet appears to decrease job inequality in Africa,[7] other than in South Africa where workers of intermediate education levels gain the most. These results underscore that the factor bias of new technologies is likely to depend on the existing distribution of skills, the technological status quo, other factors of production, and degree of labor market slackness in the relevant context.

The observed changes in job creation patterns when submarine Internet cables arrive in Africa occur through a combination of extensive margin (new users) and intensive margin (different use of the Internet by existing users when speeds increase) responses. Indeed, we find a significant increase in firm entry in sectors – technology, retail and sales, and commercial agriculture – that tend to hire workers in types of occupations that see increased job creation when fast Internet becomes available (in South Africa), and in the productivity of workers in skilled positions in existing manufacturing firms (in Ethiopia). The latter finding comes from estimating how factor output elasticities change with fast Internet, controlling for a possible simultaneous change in firm level productivity (see De Loecker, 2011), to uncover the technology's (positional) skill bias in Ethiopia. We then impose additional structure to estimate how firm level productivity responds, and find a significant increase. These productivity responses help explain why fast Internet enables Ethiopian manufacturing firms to hire more workers (especially in skilled positions). We also use firm level data from World Bank Enterprise Surveys to show that the share of sales coming from exports, use of websites, and skilled positions, is higher among firms in Ghana, Kenya, Mauritius, Nigeria, Senegal, Tanzania, and Uganda, after fast Internet becomes available.

In the final part of the paper we show that average incomes increase in the areas that see changes in job creation when fast Internet arrives. In sum, the evidence we present indicates that greater and cheaper access to information and communication due to the arrival of fast Internet increased job creation in Africa, and that in at least some countries this happened in part due to the technology's effect on firm entry, productivity, and exporting. While the impact on overall trends in structural change was likely modest, access to fast Internet appears to shift employment shares somewhat towards skilled occupations, and to decrease job inequality in Africa.

This paper is related to the literatures that focus on developing countries and analyze the relationship between globalization on the one hand and jobs, poverty, and inequality on the other; structural change; and constraints on firm growth. In the former, several important features of international trade that alter traditional models' prediction that locally relatively abundant factors gain the most from integration in the global economy were identified in the last two decades (see Feenstra & Hanson (2003); Goldberg & Pavcnik (2007); Harrison *et al.* (2011); Goldberg (2015) for overviews).[8] A parallel literature convincingly

[6] Acemoglu & Autor (2011) and Michaels *et al.* (2014) find that, if three skill levels are considered, ICT technologies substitute most for middle-skill workers in rich countries.

[7] It may for example be that the high education premium in Africa (Schultz, 2004) – due in part to the low share of highly educated workers – and time needed for educational attainment to "catch up" means that expanding sectors needing to fill skilled positions are better off hiring less educated workers and training them on the job (see also Green *et al.* , 2001; Goldin & Katz, 2008; Frías *et al.* , 2009).

[8] Interestingly, while income inequality has increased in many African countries in recent decades, the overall picture for Africa is less clear than for Asia and Latin America (Harrison *et al.* , 2011; Dabla-Norris *et al.* , 2015). Most existing studies find that globalization in the form of trade liberalization tends to increase productivity in developing countries (Goldberg & Pavcnik, 2007), with more varied effects on poverty (Topalova, 2004; Winters *et al.* , 2004) and employment rates (see e.g. Currie & Harrison, 1997; Revenga, 1997;

demonstrated SBTC's role in the slowing wage growth and rising unemployment among less educated workers in rich countries,[9] including an increase in the relative wages and productivity of high-skill workers when broadband Internet became available in Norway (Akerman *et al.* , 2015).[10] In part because similar ICT technologies were spreading outside of the West, and inequality was increasing also in most poor countries, it was widely accepted that recent technological change was partly responsible there also. The focus instead turned to possible interactions between SBTC and trade.[11] However, to our knowledge there was never any direct evidence on the causal relationship between job creation, inequality, and incomes in developing countries and the recent ICT technologies that have been shown to differentially harm low-skill workers in rich countries (Goldberg & Pavcnik, 2007).[12]

To date, research on the factor bias of new technologies in developing countries has largely focused on how technology-driven improvements in agricultural productivity affect the movement of labor in and out of agriculture (see Syrquin (1988) and Foster & Rosenzweig (2008) for overviews, and Bustos *et al.* (2016) for a prominent recent example[13]). Such movement is a form of structural change, i.e. changes in the relative size of different sectors and occupations. The key role of structural change in the process of economic development has been recognized since the early days of the field, and studied since (Clark, 1940; Lewis, 1955; Banerjee & Newman, 1993; Baumol, 2012; Herrendorf *et al.* , 2014). Recent contributions have emphasized the importance of the size of the manufacturing sector (Gollin *et al.* , 2002; Lagakos & Waugh, 2013; Gollin *et al.* , 2014; Rodrik, 2015); improvements in trends in structural change in Africa in the 2000s (McMillan & Harttgen, 2014; McMillan & Rodrik, 2014); and how trade liberalization can shift workers across firms within sectors (see e.g. Attanasio *et al.* , 2004; Davis & Harrigan, 2011), and may also have played a role in the movement of labor towards less productive sectors in Africa in the 1980s and 1990s (McMillan & Rodrik, 2014; Rodrik, 2015) (see also Baumol (2012); Young (2014)). Beyond the role of agricultural productivity and openness to trade, the causes of structural change are not well understood.

The literature investigating the drivers of firm growth in developing countries has made considerable

Harrison & Revenga, 1998; Marquez & Pages-Serra, 1998; Levinsohn, 1999; Moreira & Najberg, 2000). Currie & Harrison (1997) is an exception in that they study trade reform in Africa (Morocco). Recent evidence shows that trade benefits the poor through another a channel, i.e. because their consumption is relatively concentrated in traded goods (Fajgelbaum & Khandelwal, 2015).

[9]The relative demand for college graduates increased since the late 1980s with take-up of computers in Europe and the U.S. (Krueger, 1993; Berman & Griliches, 1994; DiNardo & Pischke, 1997; Autor *et al.* , 1998; Machin & Van Reenen, 1998; Autor *et al.* , 2003; Beaudry & Green, 2003, 2005; Beaudry *et al.* , 2010; Acemoglu & Autor, 2011; Goos *et al.* , 2014; Katz & Margo, 2014; Michaels *et al.* , 2014). The explanation lies not only in "direct" factor complementaries, but also in sorting of better workers to industries that upgrade technologically and organizational changes that favor skilled workers made possible by the use of new ICT technologies (Bartel & Sicherman, 1999; Caroli & Reenen, 2001; Bresnahan *et al.* , 2002; Crespi *et al.* , 2007; Bloom *et al.* , 2012).

[10]More generally, SBTC studies that focus on advanced Internet technology in rich countries find positive correlations with local wage levels (see e.g. Czernich. *et al.* , 2011; OECD, 2013), and mixed results for the relative wage effects in richer versus poorer U.S. counties (Forman *et al.* , 2012; Champion *et al.* , 2012; Atasoy, 2013). Atasoy (2013) finds that a U.S. county gaining access to broadband services is associated with a 1.8 percentage points higher employment rate, with larger correlations in rural and isolated areas, among college-educated workers, and in industries and occupations that more heavily utilize college-educated workers. De Stefano *et al.* (2014) find no significant effect of broadband Internet on the performance of British firms.

[11]See for example Wood (1995); Acemoglu (2003); Attanasio *et al.* (2004); Burstein & Vogel (2013); Parro (2013); Koren & Csillag (2016); Raveh & Reshef (2016).

[12]There are important existing studies of mobile phones and TV in poor countries that focus on price variation across space, risk sharing, and cultural change as outcomes (Jensen, 2007; Jensen & Oster, 2009; Aker, 2014; Chong *et al.* , 2012; Jack & Suri, 2014). Jensen (2007)'s innovative study also shows that fishermen's profits increased and consumer prices decreased when mobile phones helped eliminate price dispersion across markets in Kerala. There is also important indirect evidence on SBTC in developing countries from studies that use liberalization episodes or exchange rate variation that simultaneously affect trade and technological change for identification, including Harrison & Hanson (1999); Acemoglu (2003); Attanasio *et al.* (2004); Aghion *et al.* (2005); Amiti & Cameron (2012); Frazer (2013); Raveh & Reshef (2016). Another indirect form of evidence that has been taken to suggest that SBTC has occurred in Latin America and India in recent decades is that the share of skilled workers has increased in most industries there (see Goldberg & Pavcnik (2007, p. 27)). Goldberg & Pavcnik (2007) note that the skill premium increased around the same time as trade reform occurred in several Latin American countries and India, but that inequality *decreased* in several South East Asian countries and China when they opened up their markets (see also Wood, 1999; Wei & Wu, 2002). See also Pavcnik (2003).

[13]The Bustos *et al.* (2016) study is unusual in that the authors are able to exploit technological shocks with known within-country variation across space and time, and in that they contrast the effects of labor- and land-augmenting technologies.

progress in the last decade and a half. The benefits of importing and exporting or winning government contracts suggest that the size of the input and output markets that can be accessed is important even conditional on a firm's initial productivity (see e.g. Frías *et al.* , 2009; Goldberg *et al.* , 2010a,b; Amiti & Davis., 2012; Brambilla *et al.* , 2012; Atkin *et al.* , 2015; Ferraz *et al.* , 2015). Greater demand from richer consumers abroad has in turn been shown to enable firms to learn and to produce higher quality products that may require more skilled workers (Verhoogen, 2008; Frías *et al.* , 2009; Atkin *et al.* , 2015). Existing evidence also indicates that firm performance is enhanced by improved coordination with suppliers, access to credit, and good management (Bloom *et al.* , 2007; McKenzie *et al.* , 2008; Bloom *et al.* , 2013; Casaburi *et al.* , 2013; Macchiavello & Miquel-Florensa, 2015). But we know little about what drives job creation, productivity, and exporting among firms in developing countries. This is especially true if the focus is on the poorest countries and/or specific technologies or inputs. The existing literature reviewed here, the role of ICT in the resurgence of U.S. productivity growth since the 1990s (Draca *et al.* , 2007; Oliner *et al.* , 2007; Jorgenson *et al.* , 2008; Syverson, 2011), and a considerable body of important correlational evidence from developing countries all underscore the promise of fast Internet.[14]

Relative to the literature, we make three main contributions. First, we use quasi-random variation in access to modern ICT technology to provide direct evidence on the consequences for job creation, job inequality, and incomes in developing countries. The results are important because they suggest that the factor bias of recent technological change differs in developing countries, and that the primary explanation for the increase in inequality there in the last few decades lies elsewhere.

Second, we provide evidence on the relationship between structural change, as defined by net job creation across occupations, and ICT technology. These results represent a first step towards understanding what drives structural change, other than agricultural productivity and openness to trade. They also qualify the negative view of (other manifestations of) globalization in that fast Internet appears to increase both the share of skilled jobs and average incomes in Africa, and – at least in the Ethiopian context – productivity and employment in manufacturing.

Finally, we demonstrate how access to fast Internet affects job creation, productivity, and exporting among African firms, expanding the body of evidence on why firms tend to grow slowly, and ways to stimulate job growth, in poor countries. Our findings on fast Internet and exporting represent evidence of a form of interaction between technological change and trade that differs from trade-induced SBTC as analyzed by the existing literature.[15]

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 analyze how fast Internet affects job creation in Africa in more depth. Section 7 shows how fast Internet affects employment-related outcomes such as incomes and computer literacy. Section 8 concludes.

[14] 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. 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. 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 manufacturing firms and more extensive controls, find the same for ICT technologies. Their novel results point to much higher rates of return to investment in ICT in Brazil and India than in developed countries.

[15] Here, causality runs from technological change to trade, rather than the other way around.

2 Background

2.1 Internet infrastructure 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 "backbone" of bigger (typically fiber) cables, as depicted in Figure I for South Africa.[16] 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).[17] The submarine cables were brought to shore at various landing points along the coast, typically one in all or most countries passed by the cable. These are 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 2006 – 2014 data period as defined in Mahlknecht (2014)'s map of submarine cables.

Once plugged in, the submarine cables brought much faster speed and traffic capacities on Internet traffic to and from Europe and other continents to locations in Africa connected to the terrestrial network.[18] On a fiber-optic cable network, the technologically feasible increase in speeds and traffic 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). 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 other continents to users on network B ("tromboning"). While this partly explains the submarine cables' predicted effect on "experienced" speed and capacity, a more important fact is that "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).[19] 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. The need for African Internet traffic to travel overseas is important

[16] 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.

[17] One of the 10 submarine cables that arrived in Africa during our data period connected the continent with both Europe and India, and 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.

[18] 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.

[19] 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). Africa pays over USD 600 million a year for within-Africa traffic exchange that is carried outside the continent (Internet Society, 2013).

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.[20]

In Table I we show the mean and standard deviation of Internet speeds and use of the Internet across locations in Africa before the submarine cables arrived. The average (measured) speed was 555.58 kbps, with a standard deviation of 746 kbps. These moderately high numbers partly reflect the fact that our speed data measure non-mobile connections. (In Section 3 we describe the data in detail; some limitations of the speed measure are discussed in Sub-section 5.1). The proportion of individuals that used the Internet daily was 4.3 percent on average, with a standard deviation of 2 percent.

2.2 Jobs and Firms 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 I displays, for the groups of countries covered by our respective datasets (see Section 3), and focusing again on the period before fast Internet became available, the proportion of individuals that have a job, and the proportion that have a job in a skilled occupation. In Benin, D.R. Congo, Ivory Coast, Liberia, Nigeria, Sierra Leone, Senegal, Togo, and Tanzania (DHS countries), the employment rate is on average 62 percent, with a standard deviation of 49 percent. In Benin, Ghana, Kenya, Madagascar, Mozambique, Nigeria, Senegal, South Africa, and Tanzania (Afrobarometer countries), the employment rate is on average 58 percent, with a standard deviation of 49 percent. In South Africa, the employment rate is 71 percent, with a standard deviation of 45 percent.

In the first group of countries, 46 percent have a job that belongs to a skilled occupation as defined by the International Labour Organization (ILO), with a standard deviation of 50 percent.[21] We also observe the type of occupation that an individual is employed in in South Africa; there 49 percent have a skilled job, with a standard deviation of 50 percent.

It is worth noting that the 2006 – 2014 period we focus on was a period of high consumption and GDP per capita growth in many African countries (see also Young, 2012). In his book on 17 newly "emerging" African countries, Radelet (2011) includes seven of the 14 countries in our sample. He 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.

In the third panel of Table I, we show the average number of workers and workers in skilled positions per firm in respectively Ethiopia and Ghana, Kenya, Mauritius, Nigeria, Senegal, Tanzania, and Uganda (World Bank Enterprise Surveys countries. See Section 3 for information on the firms included). In the latter group of countries, firms have 37 employees on average, with a standard deviation of 146 across firms, while large- and medium-sized Ethiopian manufacturing firms have 80 employees on average, with a standard deviation of 223. The number of skilled positions per firm, as proxied respectively by high salary positions and non-production positions, is 24 in Ethiopia and 10 in the first group of countries.

We return to the comparison between eventually treated and untreated locations in Section 4.

[20] We exclude landlocked countries from our analysis because the extent to which they get treated (through coastal neighbors) is unclear.

[21] ILO's definition of skilled occupations is fairly wide; in Section 5.4 we separately explore each of the underlying categories.

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." Nairobi's iHub incubator had according to McKinsey Global Institute (2013) helped develop more than 150 new tech businesses by 2013. 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 global competitiveness of the country's IT industry. That was a catalyst for the explosion of Cape Town's tech scene [...] [and] stature as a business process outsourcing [BPO] and offshoring hub." 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). Growth in the tech sector also has add-on benefits in other sectors, for example construction.[22]

Nigeria is one of the African countries where "eCommerce" has taken off, driven in part by major online retailers such as Konga and Jumia (Rice, 2013), 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 from 2004 to 2014 created 100,000 direct jobs, 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 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 and computers (McKinsey Global Institute, 2013).

There are also signs that the arrival of fast Internet helped make 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, and the bureaucracy required to import and export in Ghana can now be done online, which has decreased delays considerably (McKinsey Global Institute, 2013). Such improvement in coordination along the supply chain are believed to enhance productivity in agribusiness and manufacturing. For example, the adoption of cloud-based supply-chain management solutions by the Kenyan Tea Development Agency connected around 60 tea factories with the farmers that supply them. This reportedly reduced delays at collection points and fraud, and increased both tea factories' productivity and farmers' incomes (Business Daily, 2009; GIZ, 2014)

Tech start-ups, BPO, eCommerce, new forms of manufacturing, and innovative supply-chain management companies and regulatory agencies that make doing business easier for factories and farmers are of course only examples of the ways in which fast Internet may enable greater job creation. But the technology may also eliminate jobs in some occupations, or conceivably even on average, for example due to automation or increased exposure to Asian competition. In the next section we present the data that we use to investigate the causal impact of fast Internet on job creation in Africa.

[22] Scruggs (2015) again: "In Nairobi's Kilimani neighborhood, where the tech scene is centered, ten-story office buildings clad in glass are shooting up everywhere."

3 Data

Our outcome data comes from the following sources:

Afrobarometer surveys are nationally representative repeated cross-sections conducted every two – three years in many African countries. The order in which locations are surveyed is randomly determined. We geo-code the location based on information provided on the respondent's residence. 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.[23] We also use variables on educational attainment and Internet use.

Demographic and Health Surveys (DHS) 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,[24] as well as her being employed in a specific type of occupation. We also use educational attainment variables.

The National Income Dynamics Study (NIDS) is a nationally representative sample of South African households. The order in which enumeration areas are surveyed is randomly determined. GPS coordinates for respondents are recorded. The first round of data was collected in 2008. Later survey rounds were carried out in 2010-11, 2012, and 2014-15. The survey asks questions about the livelihood of adult individuals and households.

From NIDS we construct outcome variables for the individual being employed,[25] her or his monthly income, migration status, and computer literacy.[26]

The South Africa Quarterly Labor Force Survey (QLFS) is a nationally representative repeated cross-section. Unlike in Afrobarometer, DHS, and NIDS, QLFS surveys are carried out every quarter. GPS coordinates for enumeration areas are recorded. The current version of the survey began in 2008.[27]

From QLFS we construct outcome variables for the individual being employed,[28] as well as her or him being employed in a specific type of occupation. We also use an indicator for the individual owning a business, and educational attainment variables.

South African companies are required to register with the **Companies and Intellectual Property Commission (CIPC) Firm Registry**. The resulting zip-code×date level panel registry captures total firm entry.

[23] The question states "Do you have a job that pays a cash income?".

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

[25] The question states "Are you currently being paid a wage or salary to work on a regular basis for an employer (that is not yourself) whether full time or part time?".

[26] NIDS is collected by the Southern Africa Labour and Development Research Unit. Some of the data can only be accessed on-site in Cape Town. Because three of our 10 robustness checks (excluding potentially new cables, controlling for a "placebo treatment" for 3G coverage, and using a pertubation test for inference) were carried out after the period we spent working with NIDS in South Africa, they are not done for NIDS.

[27] From 2010 quarter 3 onwards the QLFS changed the way observations are linked to enumeration areas and locations. We thus restrict attention to the period prior to then. The results are not sensitive to this decision.

[28] 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?".

CIPC provided us with data from 2007 quarter 1 to 2014 quarter 4. We code up each firm's sector when its name contains sufficient information to do so.[29]

The Ethiopia Large and Medium Scale Manufacturing Industries Survey (LMMIS) is an annual survey of the universe of Ethiopian manufacturing establishments that engage 10 or more persons and use power-driven machines. We use the 2006 to 2013 rounds. The survey collects information on 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. As proxies for skilled and unskilled positions, we use high-salary and low-salary positions.[30] When estimating production functions, we also use measures of output (value added), capital (total book value), and intermediate inputs.

The World Bank Enterprise Survey (WBES) is a nationally representative sample of formal firms with five or more employees from all sectors. The survey asks questions about the business environment, operations, output, and input use. We use WBES data from coastal countries that had survey rounds both before and after submarine cable arrival in the relevant country: Ghana, Kenya, Mauritius, Nigeria, Senegal, Tanzania, and Uganda. The surveys for these countries were carried out in 2006, 2007, 2013, and 2014.

From WBES, we use measures of output (value added), the share of total sales coming from national sales, indirect exports, and direct exports, and website and email use. As proxies for skilled and unskilled positions, we use non-production and production positions.

We also use Internet infrastructure and speed data:

We use **Mahlknecht's map of submarine cables** to measure landing points and -times (Mahlknecht, 2014), and **AfTerFibre's map of terrestrial backbone networks** to measure all locations' connectedness (AfTerFibre, 2014).[31]

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 speeds by averaging the speeds recorded for residential users, educational institution connections, government office connections, and corporate connections in a given location$\times$quarter who test their connection using Akamai's speed test website, excluding those who connect via mobile networks.[32] (We discuss an important limitation of this measurement method in Sub-section 5.1). Akamai provided us with quarterly data on average connection speeds for $\sim$900 African locations during the 2007 – 2013 period. These locations are shown in Appendix Figure A1.

4 Empirical Strategy

Our primary focus is on the relationship between economic outcomes 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

$$y_{i\mathbf{j}(i)t} = \alpha + \beta \text{SubmarineCables}_{\mathbf{j}(i)t} \times \text{Connected}_{\mathbf{j}(i)} + \delta_{\mathbf{j}(i)} + \eta_t + \epsilon_{i\mathbf{j}(i)t} \tag{1}$$

[29]The procedure we follow is described in the Appendix. We were able to assign a sector to 67% of the firms based on their names.

[30]LMMIS does not contain information on occupational categories. Skilled (high-salary) / unskilled (low-salary) positions are defined as those where salary is higher/lower than 800 Birr per year, approximately the sample salary median.

[31]Note that we consider Ethiopia (eventually) "treated" because it is well-documented that the country's backbone became internationally connected via the submarine cable landing point in Djibouti, which was planned and built to also cover Ethiopia (Giorgis, 2010; Oxford Business Group, 2015). We also consider all landing point cities connected.

[32]Since there are relatively few residential connections in Africa, this group receives little weight in the calculation.

where $y_{i\mathbf{j}(i)t}$ is an outcome for individual i in grid-cell $\mathbf{j}(i)$ and time period t. The 0.2×0.2 degree (∼20×20 km) grid-cell fixed effects – $\delta_{\mathbf{j}(i)}$ – and time period (quarter or year) fixed effects[33] – η_t – control for any time- or location-invariant shocks to employment outcomes that may be correlated with Internet connectivity. $\text{SubmarineCables}_{\mathbf{j}(i)t}$ is equal to the number of submarine cables that the backbone network in the country location $\mathbf{j}(i)$ is in is connected to at t, and $\text{Connected}_{\mathbf{j}(i)}$ is a dummy variable equal to one if location $\mathbf{j}(i)$ is connected to the backbone network. The standard errors are clustered at the grid-cell level.[34]

We define a location as "connected" if it is near terrestrial infrastructure that makes the use of fast Internet possible, i.e. the country's backbone network. (We refer to a location as "treated" at t if additionally at least one submarine cable has arrived in the country at t). Using Southwestern South Africa and the QLFS dataset as an example, Figure I displays the grid-cells that we use to define location fixed effects, the area's backbone network, as well as dots that represent the location of each enumeration area.

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* fiber-optic backbone networks to a negligible extent. Connectivity *is* lower further away from than close 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 thoughout the paper define as connected those locations in the sample that are closer to the backbone network than the median distance within the sample.[35] There are several reasons for this choice. First, dividing the sample into two groups facilitates easy inspection of possible differences in pre-trends in the outcomes across connected versus unconnected locations. Second, equal-sized "treatment" and "control" groups help to maintain statistical power to detect the impact of fast Internet.[36] 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).[37]

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. Table I includes, in addition to the overall employment rate and employment rate in skilled positions

[33] We use the quarter in which the survey was conducted (or to which the observation belongs) 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.

[34] Our results are robust to computing standard errors using methods designed to account for spatial correlation.

[35] We calculate the distance between an individual, firm 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 and NIDS, we observe the location of respectively the enumeration area to which the individual belongs (South Africa is divided into ∼80,000 enumeration areas in the QLFS sample) and the individual him- or herself. In QLFS we thus define the location of the individual as the GPS coordinates of the centroid of his or her enumeration area.

[36] It is important to note that the connectivity radius will be greater in samples that are more sparsely distributed across space relative to the backbone cables. For example, if the median distance to the backbone network in the DHS sample was used to define connectivity in regressions using the South African datasets, then nearly the entire QLFS and NIDS samples would be defined as "treated" after submarine cable arrival. This is because South Africa's backbone network is more extensive and dense than those in the DHS countries, relative to the distribution across space of surveyed individuals. Our definition of connectivity gives a connectivity radius around the backbone network of ∼2.7km for Afrobarometer; ∼19.7km for Akamai; ∼2.6km for CIPC; ∼37.5km for DHS; ∼1.04km for LMMIS; ∼4.5km for NIDS; ∼3.4km for QLFS; and ∼3.8km for WBES.

[37] Our empirical strategy may underestimate 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. It is also possible that more remote locations suffered from the greater increase in access to faster Internet in connected locations. We investigate this possibility in Sub-section 5.3.

by groups of countries covered by our respective datasets discussed in Sub-section 2.3, the breakdown by connected versus unconnected areas. Differences in employment rates are small in most countries; in the DHS and Afrobarometer countries the employment rate is respectively 2 and 3 percentage points higher in unconnected areas, while in South Africa the employment rate is 7 percentage points higher in connected areas. The rate of employment in skilled positions is 11 percentage points higher in connected areas in the DHS countries, and 8 percentage points higher in connected areas in South Africa. Firms employ 13/6 and 27/17 workers in skilled positions in connected/unconnected areas in the WBES countries and Ethiopia respectively. Internet speeds and take-up rates are also higher in connected areas.

Location fixed effects control for level differences between connected and unconnected areas. In Sub-section 5.3 we investigate possible violations of the identifying assumption of parallel trends. We show that our results are robust to varying the radius around the backbone network used to define connectivity status; to excluding backbone segments that may have been built after the arrival of submarine cables; to defining the backbone network as the intersection of maps provided by two different data sources; to excluding landing point locations; to only including eventually-treated locations in the sample; to excluding locations very near or far from the backbone network from the sample; to including "placebo treatments" that interact $\text{SubmarineCables}_{\mathbf{j}(i)t}$ with proximity to roads, electricity networks or 3G coverage; to controlling for location-specific linear and non-linear trends in the outcomes; and to including leads and lags of $\text{SubmarineCables}_{\mathbf{j}(i)t}$. We also show that the p-values on our estimates are very similar if we use a non-parametric permutation test for inference, and 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. 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. Second, the order in which different countries are reached by a given submarine cable is geographically determined. It is thus a priori unlikely that arrival times across countries correlate with temporal variation in the difference between the economic trajectories of areas on and off the backbone network in those countries.

5 Results

5.1 How submarine cable arrival affects Internet speed and use

Before analyzing how access to fast Internet affects job creation in Africa, we document that the arrival of submarine cables from Europe increases both average speeds and use of the Internet. Columns 1 and 2 of Table II shows results from running (1) with the outcome variable defined as the average Internet speed in a given location-quarter as measured in Akamai's speed data. We find that submarine cable arrival increases measured speed in connected locations, relative to unconnected locations, by about 36 percent when measured in levels, and by about 11 percent when logged. Akamai informed us that because only a fraction of their African speed tests are "sent" to servers on other continents, the estimated coefficient is likely much smaller than the true effect of the submarine cables on speeds experienced by users.[38]

[38]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, primarily speeds on traffic 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 search efforts, we have not managed to find Internet speed

In the Afrobarometer surveys, respondents are asked if they use the Internet daily, which we take as a proxy for work-related use. In columns 3 and 4 of Table II 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.[39] We find that submarine cable arrival increases the proportion of individuals that use the Internet daily in connected relative to unconnected locations by about 14 percent on average. There are likely two reasons why use of the Internet increases with submarine cable arrival. First, the technology becomes more useful to potential users. Second, 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. Of course, the increase in take-up by employers after the arrival of the submarine cables may be greater than the effect we can identify via the question asked of individuals in the Afrobarometer sample.

We conclude that both experienced speeds and use of the Internet increase considerably with the arrival of fast Internet infrastructure in Africa. These results highlight that effects on employment patterns may arise 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 occur.

5.2 Fast Internet and employment rates

In Table III we report this paper's first main findings: the estimated effect of the arrival of fast Internet on employment rates. 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 somewhat bigger 2.3 percentage point, or 4 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 1.6 percentage point or 2.3 percent increase in employment in the QLFS sample and a 1.3 percentage point or 1.9 percent increase in employment in the NIDS sample.

Given the large magnitude of these estimates, we may wonder to what extent they reflect "real" additional economic activity. A possibility is that fast Internet allows individuals to smooth out their work hours over time, without necessarily increasing the total amount of work, which could affect how they answer employment questions in a survey. In Panel B of Table III we use more detailed work-related questions available in the QLFS dataset to investigate this possibility. Fast Internet increases the probability that an individual reports that she "did work last week" by 2.9 percent and reduces the probability that she "wants to work more" by 1.8 percent. These results are hard to reconcile with a pure smoothing story.

A second possibility is that the estimates in the top panel of Table III reflect formalization of pre-existing informal jobs rather than additional job creation. But formalization is unlikely to explain our results because all four datasets ask about employment status in a way that should capture also informal employment (see Section 3). In the QLFS sample, which explicitly records both formal and informal employment, the estimated treatment effect on being formally employed is bigger than the general employment estimate reported in Table III: 0.021, with a p-value of 0.022. The estimated effect on informal employment is insignif-

data that explicitly measures speeds between specific locations in Africa and other continents over time.

[39] Note that we focus here on the effect on use of the Internet in the sample of Afrobarometer observations that overlap with the locations for which we have Akamai speed data, for comparability with the estimated effect on speed. Column 4 of Table II reports the estimated effect on Internet use in the full Afrobarometer sample, which is also significant, somewhat smaller in absolute magnitude, but of very similar magnitude to the effect found in the "speed sample" relative to the mean.

icant, with a small and positive coefficient (0.0029) on $\text{SubmarineCables}_{\mathbf{j}(i)t} \times \text{Connected}_{\mathbf{j}(i)}$.

In sum it thus appears that net job creation in Africa increases substantially when fast Internet arrives. If these estimates represent causal effects it would mean that providing access to fast Internet is among the currently known policy options with the greatest job creating potential in Africa. In the next sub-section we probe their robustness in depth.

5.3 Robustness

We start by varying the radius around the backbone network used to define connection status. In Table IV we show how the results change with both minor and bigger increases and decreases in the radius used to define connectivity. In almost all cases, the results remain highly significant and quantitatively very similar to those in Table III. In addition to confirming that the estimated effect of fast Internet is not sensitive to the definition of connectivity used, the findings in Table IV are useful 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 or migrate to 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 in treated areas. Note that we find no significant effect of access to fast Internet on migration when directly investigating this possibility.[40]

In Table V we vary the cables used to define treatment status and sample used in several ways. We first exclude segments of the backbone networks that may have been built after the arrival of submarine cables on the coast. To do so we use a map of backbone networks in Africa from www.africabandwidthmaps.com that is available both for 2009 quarter 2 and 2013 quarter 2.[41] We identify any backbone segments that www.africabandwidthmaps.com report to exist in 2013 but not in 2009 and remove these from the AfTerFibre's map that we use to define connected and unconnected locations. As seen in column 1, the results are robust to defining connected and unconnected locations based only on pre-existing backbone segments. This is unsurprising since few backbone cables were finalized and "turned on" during our relatively short data period. In column 2 we show that the results are also robust to using the intersection of the AfTerFibre and www.africabandwidthmaps.com maps from 2013 to define connectivity.

The locations that were chosen as landing points are, in addition to being on the coast, typically in or near large cities. If such locations were on a different trend in job creation before the arrival of submarine cables, we may incorrectly attribute an estimated treatment effect to the arrival of fast Internet. In column 3 of Table V we therefore exclude all individuals located closer than 20 kilometers from a landing point from the sample. The results are essentially unchanged.

In column 4 of Table V, 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 surveyed at a point in time when their location became connected to a submarine cable consists of other individuals surveyed at the same point in time but in countries that were not reached

[40] For this test we use NIDS, the only one of our outcome datasets that includes information on migration status. (DHS also includes a question on the years an individual has lived in his or her current place of residence, but the variable is missing for most of our sample). NIDS records the year in which the individual moved to his or her current place of residence. Using a variable equal to the time since the individual moved on the left-hand side in (1) gives a coefficient of 0.00908, with a standard error of 0.243, on $\text{SubmarineCables}_{\mathbf{j}(i)t} \times \text{Connected}_{\mathbf{j}(i)}$.

[41] The reason why we prefer to use AfTerFibre's map rather than the ones from www.africabandwidthmaps.com in this paper is that (1) the former is publicly and freely available, while www.africabandwidthmaps.com charge for access to their maps, and (2) AfTerFibre provide users with the GIS shape files used to construct their map and www.africabandwidthmaps.com do not. Note also that 2009 quarter 2 was the earliest period for which www.africabandwidthmaps.com were able to produce a map, but the first submarine cable during our data period arrived in Africa after that.

by a submarine cable at that time.[42] We thus prefer our baseline approach as outlined in Section 4 to the one used in column 4 of Table V, 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 connected locations are included in the sample. This result is especially supportive of our identifying assumption when viewed in combination with the QLFS and NIDS results in Table III for which we take the "opposite" approach to defining a control group. In the QLFS and NIDS samples, only individuals within the same country (and quarter) are being compared.[43]

In column 4 of Table V we exclude individuals that are either very near (<10th percentile) or very far (>90th percentile) from the backbone network. The results are essentially unchanged.

In most African countries a large part of the backbone network was built along pre-existing infrastructure such as roads or electricity cables. If locations near such infrastructure saw faster job creation over time, irrespective of whether they were also connected to the backbone network of Internet cables, there is a risk of misattributing their faster growth to the arrival of submarine cables on the coast. We thus use maps of Africa's road and electricity network to define each location's "road-connectedness" and "electricity-connectedness" status exactly as we do for Internet backbone-connectedness.[44] We interact these with the arrival of submarine Internet cables on the coast – analogously to the construction of $\text{SubmarineCables}_{\mathbf{j}(i)t} \times \text{Connected}_{\mathbf{j}(i)}$ in (1) – to construct placebo road- and electricity treatments. When these are included, the estimated effect of fast Internet remains essentially unchanged, as seen in columns 1-4 of Table VI.

In column 5 of Table VI we use the QLFS sample and 3G mobile coverage data, which is available for South Africa. We include a placebo treatment that interacts $\text{SubmarineCables}_{\mathbf{j}(i)t} \times \text{Connected}_{\mathbf{j}(i)}$ with whether the location has 3G mobile coverage at t, similarly to the approach in columns 1-4 (except that 3G coverage varies over time). The coefficient on the treatment variable for access to fast Internet falls from 0.0162 to 0.0142, and remains significant. While the benefits of fast Internet may be somewhat higher in places with better mobile connectivity, it is thus clear that Internet affects employment rates whether or not the area is covered by the 3G network.

In columns 6 and 7 of Table VI 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 QLFS dataset, in which data is collected every quarter and the panel is, as a consequence, much more balanced than our other datasets. Including these 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.

In Appendix Table A1 we include a lead and a lag of $\text{SubmarineCables}_{\mathbf{j}(i)t}$. Most of the effect of $\text{SubmarineCables}_{\mathbf{j}(i)t} \times \text{Connected}_{\mathbf{j}(i)}$ loads on the lag, indicating that it takes more than one quarter for the impact of fast Internet on job creation to arise, as we would expect. More importantly, the coefficient on the lead is negative and insignificant, supporting the assumption of parallel trends. Bertrand *et al.* (2004) pointed out that serial correlation can bias standard errors in difference-in-differences analysis. To address this concern more formally we follow Chetty *et al.* (2009) and conduct a non-parametric permutation test of $\beta = 0$. We sample from the set of true submarine cable arrival trajectories observed in the data, assigning

[42] This is because of the country-specific treatment dates. For this reason we cannot run this specification for the South Africa samples.

[43] We have also tried including country×year fixed effects in the DHS and Afrobarometer samples. The estimated coefficients and significance levels remain essentially unchanged.

[44] The GIS shapefile for African electricity grids comes from The Africa Infrastructure Country Diagnostic (AICD), and that for African road networks from the Socioeconomic Data and Applications Center (SEDAC) at the Center for International Earth Science Information Network at Columbia University.

a randomly chosen "fake" trajectory to each location while maintaining each observation's backbone connectivity status. Figure III depicts the empirical cdf of estimates resulting from permuting trajectories 500 times and running (1) on the fake datasets. The vertical lines represent the true estimates: where these fall in the empirical cdf of estimates from datasets with permuted trajectories implies their p-values. As seen in the figure, in all our datasets the true estimate is near the top of the empirical cdf. The implied p-values are 0.006 for DHS, 0.024 for Afrobarometer, and 0.03 for QLFS. These are very similar to the conventional p-values from Table III.

Finally, in Figure IV, 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. 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 the employment rate 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 III.

We conclude that the evidence suggests that the estimated effect of the arrival of fast Internet on net job creation in Africa is robust and likely represents a causal response. We now investigate how fast Internet affects structural change as measured by occupational employment shares.

5.4 Fast Internet and employment in skilled and unskilled jobs

The overall response of net job creation to the arrival of fast Internet Africa on is made up of underlying changes in job creation and destruction across specific occupations and the sectors associated with those occupation. How recent technological change affects occupational and sectoral employment shares is particularly important in poor countries that have not yet industrialized, and in an age where countries' possible paths to prosperity may include more (or less) than the historically predominant agriculture-to-industry-transition route. When exploring this question, it is important that we distinguish between *jobs* and *workers*. While none of our worker level datasets include information on an individual's past occupation(s), three of them record employed individuals' current occupation. Therefore, for example "the employment rate in occupation X" will here mean the probability of holding a job in occupation X (not the overall employment rate of workers who ("permanently") belong to occupation X). While we believe that the majority of changes in occupational employment rates when fast Internet becomes available reflects changes in the size of different sectors,[45] readers who prefer to remain agnostic can interpret the results in this Sub-section as reflecting a combination of within- and across-sector changes in skilled and unskilled net job creation.

In Table VII we use the DHS, NIDS, and QLFS datasets where occupations are labeled and can thus be categorized.[46] In the first two columns of the top panel, we define skilled and unskilled employment

[45] In addition to our belief that the low rate of tertiary education makes African workers comparatively likely to switch sectors, this is because we in Section 6 find that when fast Internet arrives there are noteworthy changes in firm entry across sectors in South Africa and a considerable expansion of the manufacturing sector in Ethiopia. On the other hand, most studies find that another form of globalization – trade liberalization – in poor regions of the world mainly shifts workers across jobs within sectors (see e.g. Revenga, 1997; Harrison & Hanson, 1999; Currie & Harrison, 1997; Attanasio *et al.* , 2004; Topalova, 2010). The literature has focused mostly on India and Latin America.

[46] Note that the NIDS dataset has severe missingness in the occupational variables. I.e., many respondents in NIDS report to have a job, but do not report the occupation to which the job belongs.

categories following the ILO's ISCO categorization of occupations' skill level. In the DHS countries – Benin, D.R. Congo, Ivory Coast, Liberia, Nigeria, Senegal, Sierra Leone, Tanzania, and Togo – the arrival of fast Internet increases the probability that an individual holds a skilled job by seven percent, and decreases the probability of unskilled employment by 11 percent. In South Africa, fast Internet increases the probability of skilled employment by seven percent in the QLFS sample and by six percent in the NIDS sample, and decreases the probability of unskilled employment by 7 percent in both the QLFS and NIDS samples. Our findings thus imply a *positional* skill bias of fast Internet in Africa that is quite similar to what has been found for computerization and fast Internet in the U.S. and Europe. The magnitude of the increase in skilled job creation is particularly noteworthy.

In columns 3-6 of the top panel in Table VII, we break the skilled category (ISCO levels 2-4) into its subcategories as defined by the ILO. There is an increase in the probability of "highly" skilled (ISCO level 4) employment in both the DHS countries and South Africa; an increase in "skilled" (ISCO level 3) employment in the South African QLFS sample; and an increase in "moderately" skilled (ISCO level 2) employment in the DHS countries and the South African NIDS sample, when fast Internet becomes available.[47]

In the bottom panel of Table VII, we consider specific types of occupations.[48] We find that fast Internet increases the probability that an individual holds a professional or a sales job, by 10 and eight percent respectively, in the DHS countries. The effect on employment in sales is noteworthy in part because it provides suggestive evidence that an increase in demand for final products, or easier electronic communication with customers, helps explain the effect on total job creation in DHS countries.[49] There is also a small increase in domestic employment, though this estimate is only marginally significant. Finally, there is a 25 percent increase in the probability of working in a position in commercial agriculture, which probably captures the growth of large-scale farms in Africa. The probability of holding an unskilled manual or a clerical job decreases in the DHS countries, while there is no significant change in the employment rate in services. Similarly, in South Africa the probability of having a professional job increases considerably,[50] as does the probability of technical employment in the QLFS sample, when fast Internet becomes available. Employment in "elementary" positions decreases in South Africa.

McMillan & Rodrik (2014) and McMillan & Harttgen (2014) show that the overall trends in structural change in Africa improved after 2000. While the low base rates must be kept in mind when interpreting the large magnitude of some of the estimates in Table VII in percent terms, they suggest that greater and cheaper access to information and communication may be among the changes in the economic environment that helped shift workers towards occupations that usually display higher productivity.[51] We return to this question in sections 6 and 7, where we investigate whether firms whose productivity increased, or who started exporting more, with the arrival of fast Internet also hired more workers, and how the technology

[47] There are no observations in the occupational categories in the "skilled" category in the DHS sample. The estimated increase in moderately skilled employment in the QLFS sample is of similar magnitude to that found in the NIDS sample, but not significant.

[48] The occupational categories observed in the three datasets are as follows. DHS: professional, clerical, sales, self-employed agriculture, employed agriculture, domestic, services, skilled manual, and unskilled manual. QLFS: legislate, professional, technical, clerical, service, skilled agriculture, craft, plant and machinery, elementary, domestic. NIDS: armed forces, manager, professional, technical, clerical, service, skilled agriculture, craft, plant and machinery, elementary. In Table VII we show results for all categories for which we find a significant effect of fast Internet in at least one of the three datasets (and the same categories are shown in Table VIII). The only exception is services, which we show because of the attention this category has received in the literature on structural change.

[49] Note, however, that an increase in demand due to the building of the submarine cables themselves cannot explain the effect on overall job creation. This is clear from the fact that our results remain largely unchanged when excluding locations near the landing points, where most of the submarine cable- driven increase in construction and related employment would have occurred.

[50] The estimated increase in professional employment is large – 21 percent – compared to a low base rate, and highly significant in the QLFS sample. The point estimate is of similar magnitude but not significant in the NIDS sample, where the baseline mean is higher.

[51] Note that there is extensive evidence that productivity is higher in large-scale/commercial agriculture in Africa than among smallholders (see e.g. Collier & Dercon, 2013).

affects average incomes in Africa. In the next sub-section we explore how job inequality in Africa responds to the arrival of fast Internet.

5.5 Fast Internet and job inequality

Given the lack of direct evidence on the factor bias of ICT in poor countries, it is a priori unclear if fast Internet affects job inequality across the educational attainment range in Africa in the same way that "computerization" has been shown to do in rich countries (Katz & Autor, 1999; Bond & Van Reenen, 2007; Goldin & Katz, 2007; Akerman *et al.* , 2015). We investigate this question in Table VIII. The initial employment rates that the estimates can be compared to are in Appendix Table A2. The table reports employment rates – overall, in skilled and unskilled jobs, and in specific occupational categories – for individuals with a completed tertiary degree, secondary school, primary school, or less than primary school, before the arrival of fast Internet. The probability of being employed in a skilled occupation rises with educational attainment, and the probability of unskilled employment falls with educational attainment, in both the DHS countries and South Africa – more so in South Africa. But it is noteworthy that individuals with less than secondary school also hold skilled jobs in Africa, for example in retail, commercial agriculture, and technical occupations, and those with tertiary or secondary education also hold unskilled jobs, for example in "elementary" occupations.

In Table VIII we report results from interacting $\text{SubmarineCables}_{\mathbf{j}(i)t} \times \text{Connected}_{\mathbf{j}(i)}$ with educational attainment. In the DHS countries the estimated rise in the overall employment rate is driven by those with less than secondary school completed. Similarly, those with secondary school or less see an increase in employment in the Afrobarometer countries. In South Africa the increase in employment is driven by those with secondary school.

In the DHS countries, all educational attainment groups see an increase in skilled employment and a decrease in unskilled employment. The changes are somewhat bigger for less educated individuals. In South Africa, skilled employment increases for individuals with secondary school.[52] The decrease in unskilled employment is driven by those with secondary school in the QLFS sample, and those with primary school or tertiary education in the NIDS sample. In interpreting these findings and the occupation specific results discussed below, it is again important to consider the base rates. For example, it is not surprising that access to fast Internet does not affect the probability of employment for South Africans with tertiary degrees since more than 90 percent of them are employed prior to the arrival of the submarine cables.

The results in Table VIII in combination with those in Table VII illuminate important similarities and differences in the way modern ICT technologies affect job inequality in Africa versus rich countries. We saw in Table VII that the skill complementarity of fast Internet as defined by its impact on net creation of high and low skill *jobs* is similar in Africa and the West. But the results in Table VIII show that fast Internet reduces job inequality across groups of *individuals* defined by their educational attainment. This result contrasts both with existing findings on computers and fast Internet as SBTC in rich countries, and with the adverse effect of another important form of globalization – trade liberalization – on inequality in developing countries (Goldberg & Pavcnik, 2007; Harrison *et al.* , 2011; Goldberg, 2015). (In South Africa – the richest country in our samples – the picture is more similar to existing findings on computerization in the West, although it is South Africans with intermediate levels of education whose employment outcomes benefit the most from fast Internet). These aspects can be understood in more detail by looking at specific occupational categories. We see for example that in the DHS countries the increase in skilled employment

[52] In the QLFS sample there is also a marginally significant smaller increase for those with primary school.

for individuals with primary school or less is primarily due to an increase in sales work, while all categories of workers see a decrease in unskilled manual employment. In South Africa those with secondary school see an increase in technical employment, and those with tertiary education a decrease in technical employment. In the DHS countries, those with secondary school or less see an increase in professional employment – albeit off of a very small base – while in South Africa the increase in professional employment is seen only for those with tertiary education. In the DHS countries there is also a relatively big increase in employment in commercial agriculture and decrease in small-scale farming, especially for less educated individuals.

Even if the comparative advantage of less educated workers lies in low-skill jobs, it is possible that fast Internet enables those workers to perform tasks they otherwise would not be able to (as exemplified by the shift of technical jobs from workers with tertiary education to workers with "only" secondary education in South Africa). If so, the arrival of the submarine cables may help "unleash" sectors that otherwise would be constrained by the low stock of highly educated workers and high education premium in Africa,[53] and to increase learning-on-the-job (Green *et al.* , 2001; Schultz, 2004; Frías *et al.* , 2009). In Section 7 we explore how access to fast Internet affects computer literacy in South Africa.

Finally, in Table IX we compare how fast Internet affects employment rates for women versus men. The DHS sample we use covers only women so our findings for the DHS countries are for female employment. In the sample of Afrobarometer countries the effect size is somewhat bigger for men than for women. In the two South African samples the effect is bigger and significant only for women, but the estimate for men is of similar magnitude to that found in the full samples so that the fact that the estimates for men are insignificant in the South African samples appears to be due to power issues. The bigger increase in employment for women than men in South Africa, relative to in other African countries, is another aspect in which our estimates for the richest country we consider more closely resembles existing findings on SBTC in the West (see Black & Spitz-Oener, n.d.).

In the next Section we investigate *how* fast Internet affects job creation in Africa.

6 Understanding how Fast Internet Affects Job Creation in Africa

6.1 Firm entry and business ownership

The observed changes in average speeds and use of the Internet after the arrival of the submarine cables suggest that new, and new forms of, job creation may occur both through extensive margin (new Internet users) and intensive margin (different use of the Internet by existing users when speeds increase) responses. In this sub-section we analyze how fast Internet affects firm entry across sectors and business ownership; in the next two sub-sections we explore possible changes in the productivity and exports of existing firms.

We use South Africa's CIPC dataset, which records firm registrations by zip-code, date, and firm type, and the QLFS, which records business ownership. As seen in Table X, the estimated effect on overall firm entry is small and insignificant, as is the effect on new manufacturing firms. We do, however, find a significant four percent increase in new firms in the technology sector; a three percent increase in new agricultural firms; and a nine percent increase in new retail and sales firms.

These sectoral responses in firm entry correspond remarkably well to changes in the number of workers employed in the associated occupations we documented in Sub-section 5.4.[54] They also reinforce the view

[53] Such a scenario could increase incentives for educational attainment, but it takes time for the stock of educated workers to "catch up" (Goldin & Katz, 2008).

[54] Recall that we found an increase in the probability of working in technology occupations in South Africa (where the QLFS and

that fast Internet's effect on structural change was at least partly positive insofar as productivity in the technological and agribusiness sectors is likely high relative to other sectors in South Africa. Finally, the increase in new retail and sales firms corroborates the findings from Sub-section 5.4 pointing towards an increase in demand for final products with the arrival of fast Internet as part of the explanation for increased job creation.

Table X also shows the estimated effect of fast Internet arrival on business ownership in South Africa. While relatively large relative to the baseline mean, the estimate is not significant.

6.2 Firm and labor productivity in existing firms

6.2.1 OLS results

We have seen that access to fast Internet affects firm entry in certain sectors, which appears to contribute to its impact on job creation. Does the new technology also affect job creation within existing firms, and, if so, why? To investigate these questions we first use Ethiopia's LMMIS dataset of large and medium- sized manufacturing firms, which is to our knowledge the only African dataset with detailed enough information and the geographical and time coverage needed to estimate changes in firms' production function after the arrival of fast Internet. We restrict the sample to firms that are observed both before and after the submarine cable that gets connected to Ethiopia's backbone network arrives on the coast.

In columns 1-3 of Table XI, we continue to use the same specification and definition of right hand- side variables as in (1), but i now represents a firm and observations are at the firm$\times$year level.[55] In the first column, the outcome variable is the log total number of employees at the firm. We find that access to fast Internet leads to a 14.5 log point increase in the number of workers per firm in Ethiopia. In columns 2 and 3 the outcome variables are our proxies for the number of skilled and unskilled positions per firm (as discussed in Section 3, these are based on salary bins). The estimated increase in workers in skilled positions is 13.9 log points and marginally significant. The estimated increase in workers in unskilled positions, while also positive, is smaller and not significant. The firm level estimates of changes in employment when fast Internet arrives in Ethiopia are thus qualitatively comparable to the individual level employment results for the broader samples of African countries and South Africa in Section 5.

In the remaining columns of Table XI we explore whether the increase in employment in Ethiopian manufacturing firms may be explained by an increase in the output elasticity of labor and/or firm level productivity with the arrival of fast Internet. We follow Akerman *et al.* (2015) and start with the following OLS regression:

$$\text{va}_{ijt} = x'_{ijt}\alpha + \text{SubmarineCablesConnected}_{ijt}x'_{ijt}\beta + \psi_j + \eta_t + \epsilon_{ijt} \tag{2}$$

where va_{ijt} is the log value added of firm i in industry j in year t, x'_{ijt} is a set of inputs (labor, capital) used by the firm and a constant term, ψ_j is an industry fixed effect, and the other variables are as defined previously.[56] Results from this specification are in columns 4 and 5 in Table XI. The coefficients on capital

NIDS datasets do not record agricultural and retail employment), and in retail and commercial agriculture in the DHS countries (where the DHS dataset does not record technology employment).

[55] To be consistent with the production function regressions, we also include an industry fixed effect, as is standard.

[56] Since only one submarine cable reaches Ethiopia during our data period, SubmarineCablesConnected is now a dummy variable. Note that to ease comparison with the structural results also presented in Table XI, we interact only labor and the constant term with $\text{SubmarineCablesConnected}_{ijt}$. If the interaction between capital and $\text{SubmarineCablesConnected}_{ijt}$ is also included, the other estimated coefficients remain almost exactly unchanged and the estimated coefficient on capital$\times\text{SubmarineCablesConnected}_{ijt}$ is near

and labor are of similar magnitude to what other studies have found for comparable contexts (see e.g. Söderbom, 2004). The estimated change in the output elasticity of total labor with the arrival of fast Internet is small but actually marginally significantly negative. The estimated output elasticity of labor in skilled positions increases significantly, from 46.4 to 54.3 log points, but that of labor in unskilled positions falls. If accurate these estimated changes in the output elasticity of workers in skilled and unskilled positions may help to explain the changes in employment in skilled and unskilled positions seen in Section 5 and columns 2 and 3 of Table XI.

6.2.2 Structural estimation

OLS estimates of the share of variation in output attributable to different input factors may partly reflect the fact that some input factors – such as labor – are chosen after a firm's productivity (unobserved to the researcher) is fully or partially known to the firm. Olley & Pakes (1996) (OP) and Levinsohn & Petrin (2003) (LP) developed practical methods that help overcome such simultaneity bias. The commonly used LP method involves using intermediate inputs to proxy for a firm's unobserved productivity in the production function (see LP for details). Suppose now we posit the following "structural" model:

$$\text{va}_{ijt} = l_{ijt}\theta + \text{SubmarineCablesConnected}_{ijt} l_{ijt}\phi + \kappa k_{ijt} + \omega_{ijt} + \epsilon_{ijt} \tag{3}$$

where l_{ijt} are labor inputs and the productivity term ω_{ijt} subsumes the constant term and the fixed effects. ϵ_{ijt} represents a standard i.i.d. error term capturing unanticipated shocks to productivity and measurement error. We present LP estimates in columns 6 and 7 of Table XI. As expected, the coefficient on capital is now bigger than the OLS estimate, while both $\hat{\theta}$ and $\hat{\phi}$ are now smaller in magnitude and $\hat{\phi}$ is not significant. The coefficients on the interaction between access to fast Internet and skilled and unskilled labor falls from 0.079 to 0.042 and from -0.17 to -0.039 respectively, but remain significant.

De Loecker (2011) points out a methodological tension when using the OP/LP methods to investigate how a change in the operating environment affects output elasticities. Suppose that a firm's productivity *itself* is influenced by the change in the operating environment. If the productivity response in turn influences hiring, investment and value added – as most conventional models of firm behavior would predict, and consistent with the results we have seen so far in Table XI – then changes in the coefficients on labor and capital estimated using methods that do not account for the firm level productivity response will be incorrect.

Inspired by De Loecker (2011), we assume the following law-of-motion for productivity:

$$\omega_{ij,t+1} = \alpha\omega_{ijt} + \tau\text{SubmarineCablesConnected}_{ijt+1} + \psi_j + \eta_t + \xi_{ij,t+1} \tag{4}$$

We continue to use the LP estimation procedure, but adjust the method to allow both the output elasticities of labor and firm level productivity itself to change. We first estimate ϕ while controlling for a possible response in firm level productivity to fast Internet. As in the conventional LP method, we use a flexible polynomial in the other input factors – including intermediate inputs – to proxy for ω_{ijt}. The adjustment we make in this first step is that we include $\text{SubmarineCablesConnected}_{ijt}$ among the factors included in the polynomial. We run:

zero and insignificant. The only difference is that the coefficient on labor$\times$SubmarineCablesConnected$_{ijt}$ falls slightly in magnitude and becomes insignificant.

$$\text{va}_{ijt} = l_{ijt}\theta + \text{SubmarineCablesConnected}_{ijt} l_{ijt}\phi + \Psi\left[m_{ijt}, k_{ijt}, \text{SubmarineCablesConnected}_{ijt}, \psi_j, \eta_t\right] + \epsilon_{ijt} \tag{5}$$

where $\Psi\left[m_{ijt}, k_{ijt}, \text{SubmarineCablesConnected}_{ijt}, \psi_j, \eta_t\right]$ is a polynomial of inputs used (m_{ijt}), capital (k_{ijt}), access to fast Internet, and industry and time fixed effects.

The estimated effect of fast Internet on the output elasticity of labor and labor in skilled and unskilled positions estimated through this procedure is reported in columns 6 and 7 of Table XI. The estimated change in the output elasticity of total labor remains small and insignificant. The estimated decrease in the output elasticity of labor in unskilled positions increases in absolute magnitude to -0.074 and remains significant. The estimated increase in the output elasticity of labor in skilled positions is very similar to the estimate from the conventional LP method – 0.04 – and remains significant.

In the second step the coefficient on capital is estimated by GMM using the moment condition $\mathbb{E}\left[\xi_{ijt}(\kappa)\ k_{ijt}\right] = 0$, which is motivated by the assumption that capital cannot be adjusted in response to unobserved shocks to productivity.[57] For ω_{ijt} we use the OLS residual from a version of (3) that substitutes in predicted value added for va_{ijt} and the labor coefficients estimated in the first step, and for $\hat{\xi}_{ij,t+1}$ we use the OLS residual from (4).

For our purposes the coefficient on capital is needed only as an input into the procedure for estimating how fast Internet affects firm level productivity. With estimates of the coefficients on labor, capital, and the interaction between labor and $\text{SubmarineCablesConnected}_{ijt}$ in hand, we can construct $\hat{\omega}_{ijt}$ using (3) and then estimate the law-of-motion for productivity in the third step. The results are reported in columns 8 and 9 of the bottom panel of Table XI. The estimated increase in firm level productivity when fast Internet becomes available is 14.6 log points when we do not distinguish between labor in skilled and unskilled positions and 19.4 log point when we do, and significant in both cases. We conclude that an increase in the output elasticity of labor in skilled positions and firm level productivity likely contribute to increased hiring in existing Ethiopian firms after the arrival of fast Internet.

6.3 Exporting

In Table XII we use data from the World Bank Enterprise Surveys to explore how the arrival of the submarine cables affects firms in Ghana, Kenya, Mauritius, Nigeria, Senegal, Tanzania, and Uganda, especially their ability to export. We first show that access to fast Internet has no significant effect on the total number of employees, nor on the number of workers in unskilled positions as proxied by production positions, in WBES firms. However, we find a significant seven percent increase in employees in skilled positions as proxied by non-production positions, with the arrival of fast Internet.

In column 4 of Table XII we explore how fast Internet affects value added at WBES firms. While the estimated effect is not significant, the point estimate is positive and large – ∼15 percent – so that we cannot rule out a relatively sizable effect on value added.

More firms answer questions about the share of their sales made up of domestic sales, indirect exports, and direct exports, giving us greater power to explore how these respond. We find a significant 2.1 percent decrease in the share of sales made in-country; no effect on indirect exports; and a significant 1.6 increase in the share of sales coming from exports, when fast Internet becomes available. In light of the existing literature documenting the benefits to firms and workforce consequences of exporting (see e.g. Verhoogen,

[57] We use the OLS estimates as starting values, and bootstrapped standard errors.

2008; Frías *et al.* , 2009; Goldberg *et al.* , 2010b; Atkin *et al.* , 2015), these findings suggest that one way in which the technology helps create more skilled jobs is by making it easier for firms to sell to customers abroad. They also represent evidence of a form of interaction between technological change and trade that differs from the trade-induced SBTC analyzed by an existing literature (Wood, 1995; Acemoglu, 2003; Attanasio *et al.* , 2004; Koren & Csillag, 2016). Here, causality runs from technological change to trade, rather than the other way around.

Unlike our other datasets, WBES also contains information on firms' use of the Internet. As seen in columns 8 and 9 of Table XII, we find a marginally significant 18 percent increase in communication via a website, but no significant change in communication by email, when fast Internet arrives.

In sum, we have seen evidence in this section indicating that the increase in net job creation when fast Internet arrived in Africa was driven in part by greater firm entry in the commercial agriculture, retail, and technology sectors in South Africa; by increased worker and firm level productivity in existing Ethiopian manufacturing firms; and by greater exports and use of websites among firms in the WBES countries. While the magnitudes of these economic responses is important in their own right, data limitations prevent us from investigating what *share* of the changes in employment patterns they account for. Additional mechanisms likely also played a role.[58]

7 Employment-related Consequences of the Arrival of Fast Internet

Some would consider jobs a means to an end more than an end in itself. In Table XIII we explore how important "ultimate" economic outcomes respond to the arrival of the submarine cables. We focus on incomes – measured both at individual and location level – and computer literacy. Increasing access to, and lowering the cost of, information and communication may affect incomes and technological human capital accumulation also through other channels than employment outcomes. But to the extent that fast Internet affects overall and skilled job creation, we would a priori also expect such increased (good) job creation to ultimately affect incomes and learning-on-the-job.

In column 2 of Table XIII we use income data for South African individuals surveyed in NIDS. This variable is available only for employed individuals so that any effect of fast Internet must arise either through changes in jobs held, or an increase in earnings for individuals who do not change jobs. We see that individual incomes among the employed rise by about 5 percent with the arrival of fast Internet in South Africa.

In column 1 we follow a growing literature and proxy for average incomes at location level with light density at night as measured by satellites (see e.g. Henderson *et al.* , 2012; Bleakley & Lin, 2012; Michalopoulos & Papaioannou, 2013; Lowe, 2014b). In addition to capturing the *aggregate* economic benefits of fast Internet, an advantage of this income proxy is that it is available for all 14 countries in our sample. We construct grid cell–year level measures of average light density at night using satellite images from the National Oceanic and Atmospheric Administration. The estimating equation is (1) as throughout the paper, although no i subscript is required. We see that light density at night rises by about 2 percent when fast Internet becomes available. It thus appears that fast Internet's impact on job creation ultimately contributes to an increase in average incomes in Africa.

[58]For example, Hardy & McCasland (2015) show that small firms in Ghana are labor constrained. Fast Internet may help ease information frictions and make it easier for employers and suitable job-seekers to find each other through online job boards or work platforms. We leave investigation of such possibilities for future research.

In columns 3-5 of Table XIII, we show that there is also a significant improvement in computer literacy: individuals are less likely to be computer illiterate, and more likely to have basic or high computer literacy when fast Internet arrives. This finding provides further evidence that fast Internet enables African workers of a given education level to perform tasks they otherwise would not be able to. This is likely part of the explanation why the technology simultaneously facilitates the creation of more skilled jobs and decreases job inequality for more versus less educated workers.

8 Conclusion

This paper provides evidence on how fast Internet affects job creation in Africa. We exploit the gradual arrival of 10 submarine Internet cables from Europe in cities on Africa's coast between 2006 and 2014 and interact landing points and -times with an indicator for whether a given location is on the terrestrial cable network that connects users with the coast. We first show that both average speeds and use of the technology increase when the submarine cables arrive. We then compare the changes in employment patterns in cities and towns with a bigger versus a smaller increase in access to fast Internet, controlling for location and time fixed effects. In each of four different datasets that together cover 14 African countries with a combined population of roughly half a billion people, we find a significant increase – of 1.9 to 4 percent – in the overall employment rate when fast Internet becomes available. Extensive prodding of the identifying assumptions that underlie our "dynamic" difference-in-differences approach suggests that these estimates reflect a causal effect of access to fast Internet on job creation. The technology reduces employment in unskilled jobs, but enables a bigger increase in jobs in higher-skill occupations. Fast Internet also lowers job inequality, as defined by differences across the educational attainment range in having a job and/or a "good" job, in Africa.

The observed changes in average speeds and use of the Internet after the arrival of the submarine cables suggest that new and new types of jobs may have been created both via "extensive margin" (new Internet users) and "intensive margin" (different use of the Internet by existing users when speeds increase) responses. We explore these possibilities with more detailed firm level datasets available for some countries. In South Africa there was increased firm entry in the sectors associated with the occupations that saw higher employment rates continent-wide, and in Ethiopia we document an increase in the productivity of of workers in skilled positions and firm level productivity in existing manufacturing firms when fast Internet became available. We also show that fast Internet enabled firms in Ghana, Kenya, Mauritius, Nigeria, Senegal, Tanzania, and Uganda to export more, in part by using websites.

These findings indicate that the (positional) skill bias of recent technological change differs in developing countries from what has been found for "computerization" and fast Internet in rich countries.[59] This in turn indicates that the primary explanation for the slow economic progress of poor workers in many developing countries during the last few decades is not "skill-biased" technological change. The sectors that ex ante appear to have been most constrained by lack of access to ICT, and that create more "good" jobs when fast Internet becomes available, are for the most part ones associated with high productivity relative to other sectors in Africa. In at least some of these sectors in some parts of the continent, the technology increases productivity further, and enables exporting. This suggests that fast Internet contributed positively to structural change in Africa during our data period.

[59] Interestingly, in South Africa, the richest country in our sample, the heterogeneity across types of individuals in the impact of the technology is more similar to what has been found in the West.

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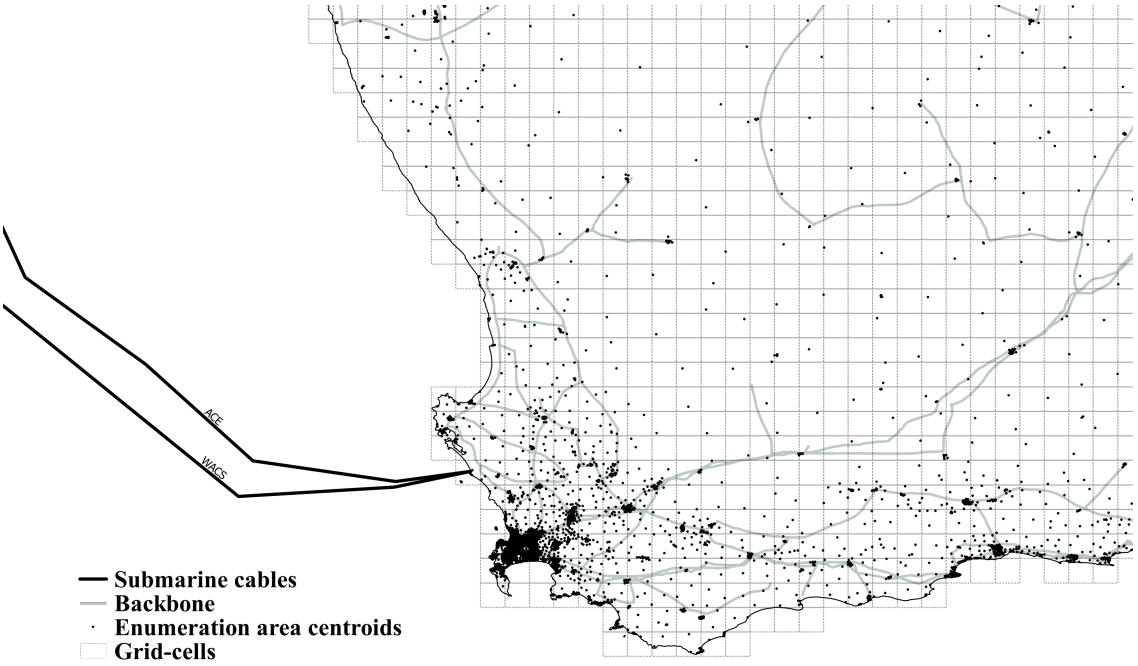
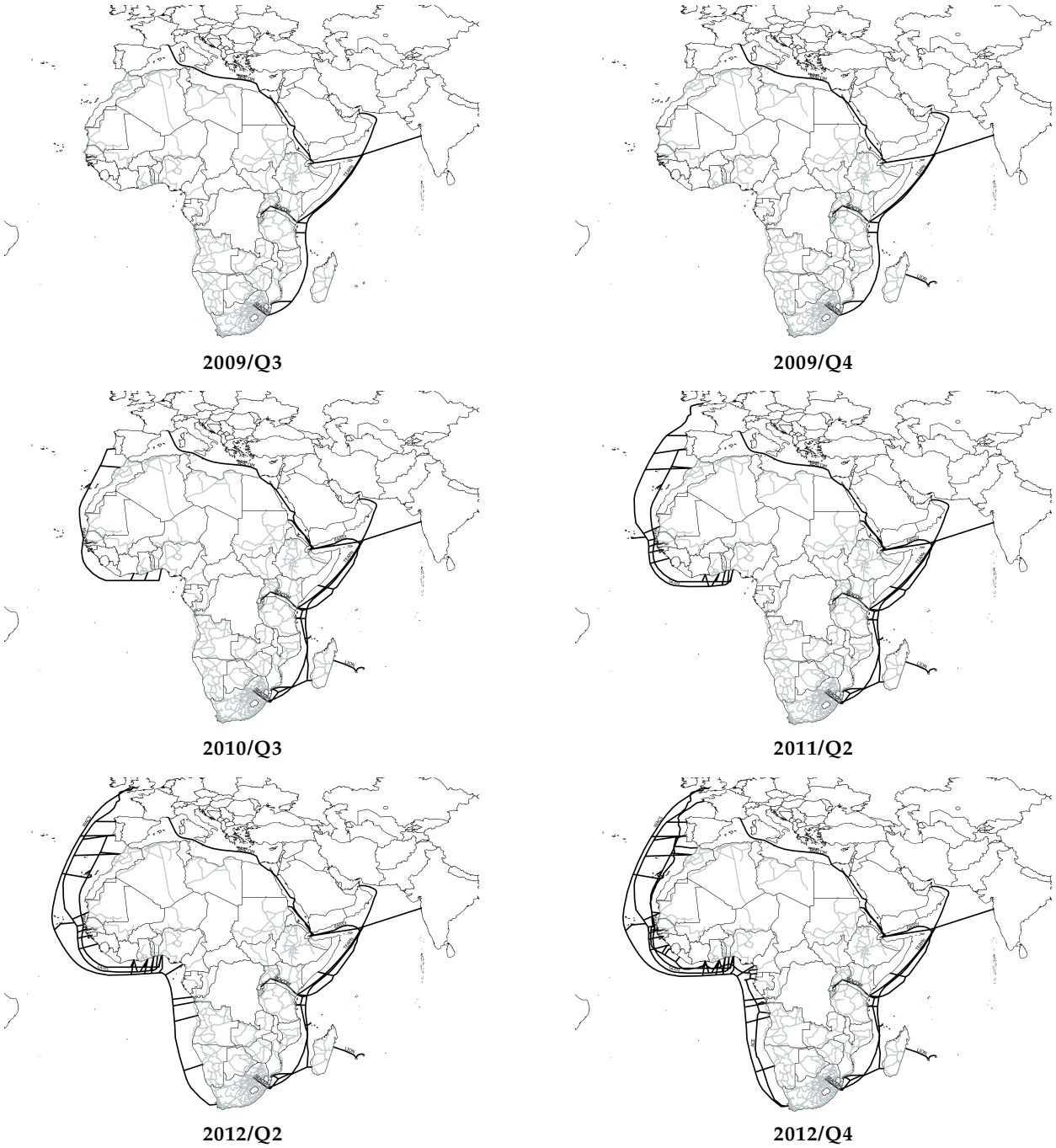
Figures

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



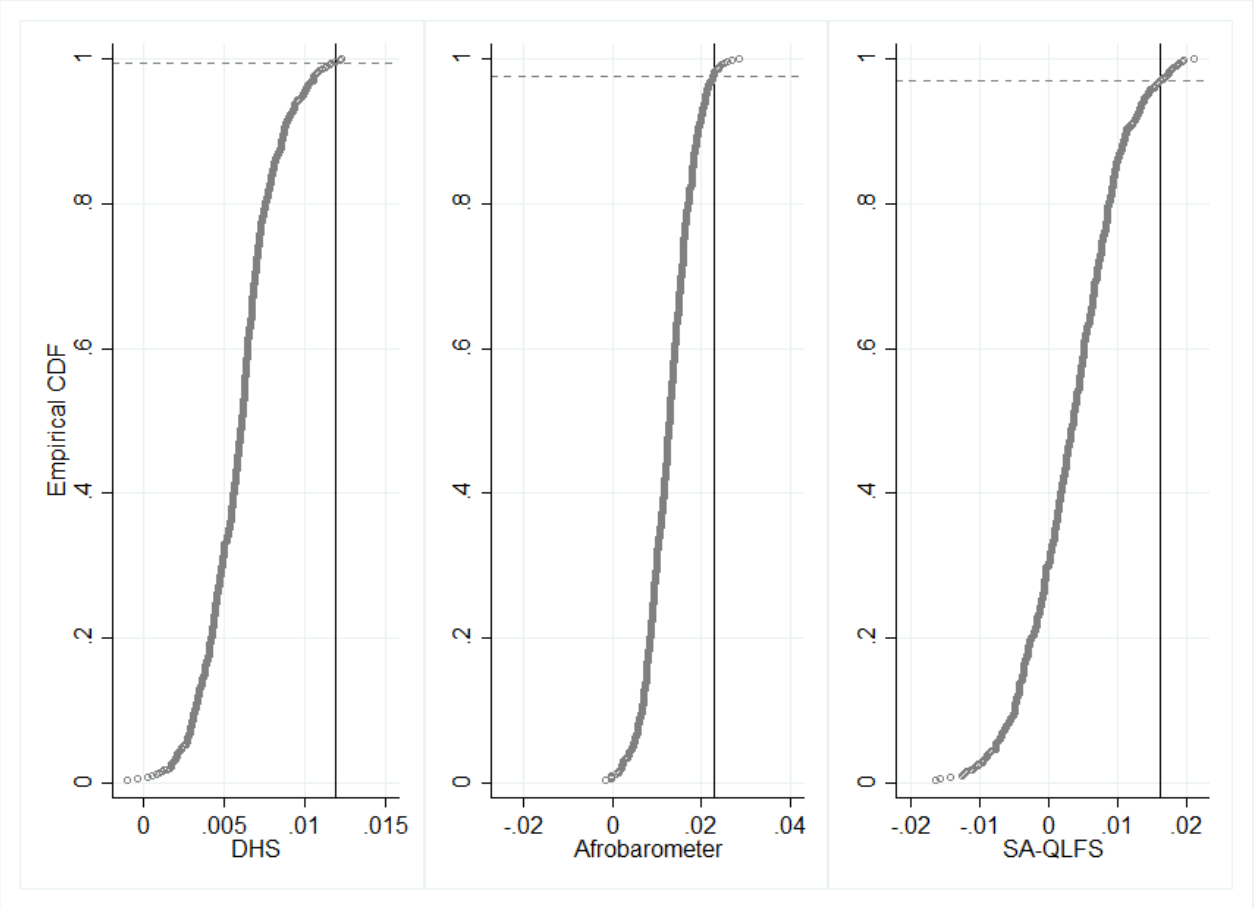
This figure shows two submarine cables arriving to Yzerfontein, just north of Cape Town in South Africa, the country's terrestrial backbone network, and centroids of the QLFS enumeration areas. Grid-cells are 0.2×0.2 decimal degrees.

FIGURE II: SUBMARINE INTERNET CABLE ARRIVAL IN AFRICA, 2006-2014



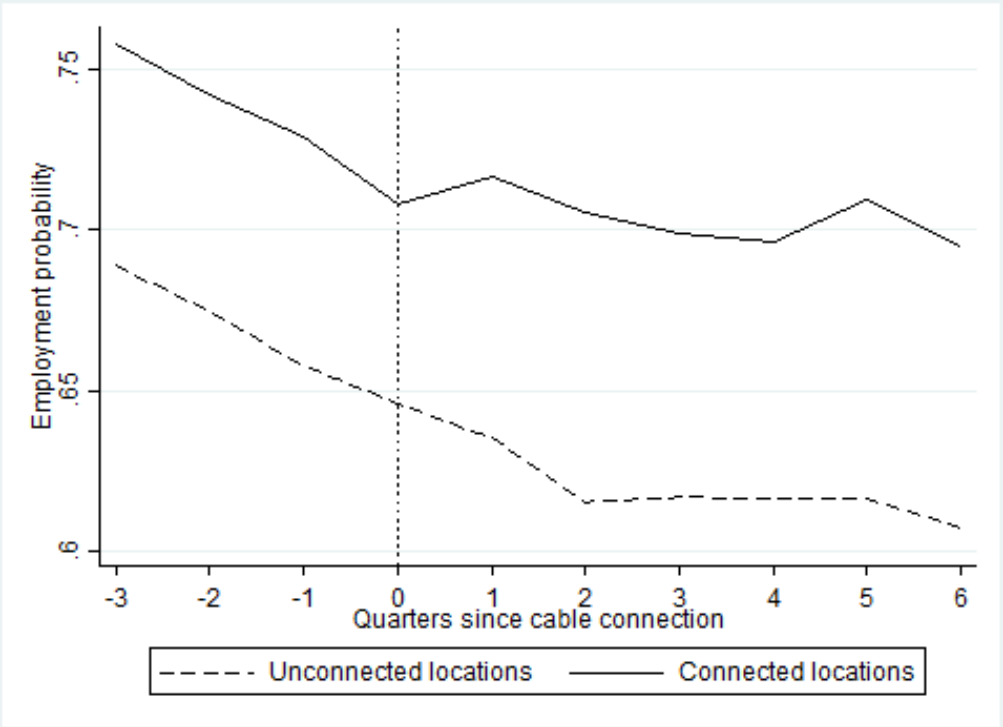
This figure shows the arrival of submarine Internet cables over time. The first two cables in our sample period arrived in 2009/Q3 and the last in 2012/Q4. The submarine cables are Seacom and Teams (2009/Q3), Lion (2009/Q4), Eassy and MainOne (2010/Q3), Glo1 (2011/Q2), WACS (2012/Q2) and ACE (2012/Q4).

FIGURE III: DISTRIBUTION OF PLACEBO ESTIMATES: FAST INTERNET AND EMPLOYMENT



This figure shows a non-parametric permutation test of $\beta = 0$. We sample from the set of true submarine cable arrival trajectories observed in the data, assigning a randomly chosen "fake" trajectory to each location while maintaining each observation's backbone connectivity status. There are 15 potential trajectories and they are assigned with equal probability. The figure depicts the empirical cdf of estimates resulting from permuting trajectories 500 times and running equation (1) on the fake datasets. The vertical lines represent the true estimates; where these fall in empirical cdf of estimates from datasets with permuted trajectories implies their p-values. The implied p-values are 0.006 for DHS, 0.024 for Afrobarometer, and 0.03 for QLFS. These can be compared to 0.009, 0.000, and 0.021 from Table III.

FIGURE IV: EMPLOYMENT RATE IN CONNECTED AND UNCONNECTED LOCATIONS IN SOUTH AFRICA BEFORE AND AFTER FAST INTERNET ARRIVAL



This figure plots the employment rate in connected and unconnected locations in South Africa before and after the first submarine cable in our data period arrived in the country (2009/Q3).

Tables

TABLE I: INTERNET SPEED AND TAKE-UP, AND EMPLOYMENT OUTCOMES, BEFORE SUBMARINE CABLE ARRIVAL

	Connected	Unconnected	All
INTERNET			
Internet speed (KB/sec)	567.55	540.77	555.58
	[784.3]	[698.2]	[746.0]
Daily internet use	0.050	0.035	0.043
	[0.22]	[0.18]	[0.20]
EMPLOYMENT OUTCOMES – WORKER LEVEL			
Benin, D.R. Congo, Ivory Coast, Liberia, Nigeria, Sierra Leone, Senegal, Togo, Tanzania (DHS)			
Employment	0.61	0.63	0.62
	[0.49]	[0.48]	[0.49]
All skilled	0.51	0.40	0.46
	[0.50]	[0.49]	[0.50]
Benin, Ghana, Kenya, Madagascar, Mozambique, Nigeria, Senegal, South Africa, Tanzania (Afrobarometer)			
Employment	0.56	0.59	0.58
	[0.50]	[0.49]	[0.49]
South Africa (QLFS)			
Employment	0.74	0.67	0.71
	[0.44]	[0.47]	[0.45]
All skilled	0.53	0.45	0.49
	[0.50]	[0.50]	[0.50]
EMPLOYMENT OUTCOMES – FIRM LEVEL			
Ghana, Kenya, Mauritius, Nigeria, Senegal, Tanzania, Uganda (WBES)			
# employees	43.6	28.3	37.4
	[157.5]	[127.0]	[146.0]
# skilled positions	12.6	6.33	10.2
	[48.4]	[25.8]	[41.3]
Ethiopia (LMMIS)			
# employees	88.96	58.78	79.69
	[233.87]	[296.21]	[223.40]
# skilled positions	27.34	17.17	24.22
	[110.30]	[112.28]	[110.99]

Internet speed data comes from Akamai and is measured prior to submarine cable arrival, in 2007/Q3. We restrict to locations with an IP count above 5. Internet use rates come from Afrobarometer. Employment rates are from Demographic Health Surveys (DHS), Afrobarometer, and South African Quarterly Labor Force Surveys (QLFS), and are measured prior to submarine cable arrival. Firm data are from the Ethiopia Large and Medium Scale Manufacturing Industries Survey (LMMIS), and the World Bank Enterprise Survey (WBES), and are measured measured prior to submarine cable arrival. Occupational skill levels in DHS and QLFS are defined according to ISCO standards (ILO). In WBES, skilled positions are proxied by the number of non-production employees. In LMMIS, skilled positions are defined as those where earnings are more than 800 Birr per year (roughly the sample salary median). Individuals (locations) are considered connected if they are closer than the median individual (location) in the relevant sample to the backbone networks. Standard deviations are shown in square brackets.

TABLE II: EFFECT OF SUBMARINE CABLE ARRIVAL ON INTERNET SPEED AND TAKE-UP

	Internet speed in levels	**Internet speed in logs**	**Internet usage speed sample**	**Internet usage full sample**
Unit of analysis:	City (KB/second)	City (Log KB/second)	Individual (0/1)	Individual (0/1)
SubmarineCables×Connected	290.072***	0.109***	0.012**	0.006*
	(79.420)	(0.025)	(0.005)	(0.003)
Mean of outcome	813.4		0.085	0.0429
Time FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	No
Grid-cell FE	No	No	No	Yes
Observations	8,809	8,809	9,543	17,743

This table uses quarterly Internet speed data from Akamai and annual Internet usage data from Afrobarometer. Internet speed is defined in kilobits per second. Use is equal to one if an individual states that she uses the Internet daily (our proxy for work-related Internet use). Column 2 shows the results when Afrobarometer locations are matched to Akamai locations using a ∼22 km radius (0.2 decimal degree) around the latter, while column 3 shows the estimate for all Afrobarometer observations. Grid-cells are 0.2×0.2 decimal degrees. Individuals (locations) considered connected if within median distance of the backbone network. OLS regressions. Robust standard errors clustered at location level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE III: FAST INTERNET AND EMPLOYMENT

	DHS	Afro-barometer	SA-QLFS	SA-NIDS
Unit of analysis:	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)
SubmarineCables×Connected	0.012***	0.023***	0.016**	0.013**
	(0.005)	(0.006)	(0.007)	(0.006)
Mean of outcome	0.620	0.579	0.711	0.696
Time FE	Yes	Yes	Yes	Yes
Grid-cell FE	Yes	Yes	Yes	Yes
Observations	152,674	12,683	322,957	37,558
Work-related Outcomes from SA-QLFS				
	Did work last week	**Wants to work more**		
Unit of analysis:	Individual (0/1)	Individual (0/1)		
SubmarineCables×Connected	0.010*	-0.012*		
	(0.006)	(0.006)		
Mean of outcome	0.344	0.666		
Time FE	Yes	Yes		
Grid-cell FE	Yes	Yes		
Observations	556,870	547,496		

DHS sample includes Benin, D.R. Congo, Ivory Coast, Liberia, Nigeria, Senegal, Sierra Leone, Tanzania and Togo. Afrobarometer sample includes Benin, Ghana, Kenya, Madagascar, Mozambique, Nigeria, Senegal, South Africa and Tanzania. Grid-cells are 0.2×0.2 decimal degrees. Individuals (locations) considered connected if within median distance of the backbone network. OLS regressions. Robust standard errors clustered at grid-cell level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE IV: FAST INTERNET AND EMPLOYMENT, VARYING CONNECTION RADIUS

	DHS	Afro-barometer	SA-QLFS	SA-NIDS
Unit of analysis:	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)
SubmarineCables×Connected, baseline × .5	0.004	0.022***	0.020***	0.004
	(0.004)	(0.008)	(0.008)	(0.007)
SubmarineCables×Connected, baseline × .7	0.007	0.020***	0.015**	0.008
	(0.00450)	(0.00674)	(0.00692)	(0.00686)
SubmarineCables×Connected, baseline × .9	0.010**	0.022***	0.014**	0.011*
	(0.005)	(0.007)	(0.007)	(0.006)
SubmarineCables×Connected, baseline × .95	0.012**	0.022***	0.017**	0.012**
	(0.005)	(0.006)	(0.007)	(0.006)
SubmarineCables×Connected, baseline × .97	0.011**	0.022***	0.017**	0.014**
	(0.005)	(0.006)	(0.007)	(0.006)
SubmarineCables×Connected, baseline × .99	0.012**	0.022***	0.016**	0.012**
	(0.005)	(0.006)	(0.007)	(0.006)
SubmarineCables×Connected, baseline radius (median)	0.012***	0.023***	0.016**	0.013**
	(0.005)	(0.006)	(0.007)	(0.006)
SubmarineCables×Connected, baseline × 1.01	0.011**	0.019***	0.015**	0.014**
	(0.005)	(0.007)	(0.007)	(0.006)
SubmarineCables×Connected, baseline × 1.03	0.012***	0.019***	0.016**	0.015**
	(0.005)	(0.007)	(0.007)	(0.006)
SubmarineCables×Connected, baseline × 1.05	0.012***	0.020***	0.015**	0.015**
	(0.005)	(0.007)	(0.007)	(0.006)
SubmarineCables×Connected, baseline × 1.1	0.013***	0.019***	0.015**	0.015**
	(0.005)	(0.007)	(0.007)	(0.007)
SubmarineCables×Connected, baseline × 1.3	0.014***	0.019***	0.014*	0.016**
	(0.005)	(0.007)	(0.007)	(0.007)
SubmarineCables×Connected, baseline × 1.5	0.015***	0.016**	0.011	0.022***
	(0.005)	(0.007)	(0.008)	(0.007)
Mean of outcome	0.620	0.579	0.711	0.696
Time FE	Yes	Yes	Yes	Yes
Grid-cell FE	Yes	Yes	Yes	Yes
Observations	152,674	12,683	322,957	37,558

For baseline radius, individuals (locations) considered connected if within median distance of the backbone network. Rows above baseline radius row decrease the connection radius, while rows below increase it. OLS regressions. Grid-cells are 0.2×0.2 decimal degrees. Robust standard errors clustered at grid-cell level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE V: FAST INTERNET AND EMPLOYMENT, VARYING THE SAMPLE AND TERRESTRIAL CABLES CONSIDERED

	Excluding potentially new cables	**Excluding cables not reported by both**	**Excluding areas close to landing station**	**Excluding never connected areas**	**Excluding distance tails**
Unit of analysis:	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)
SubmarineCables×Connected, DHS	0.013***	0.010**	0.009**	0.030*	0.014***
	(0.005)	(0.005)	(0.004)	(0.016)	(0.005)
Mean of Outcome	0.620	0.620	0.643	0.644	0.645
Observations	152,674	152,674	135,517	75,138	122,915
SubmarineCables×Connected, Afrobarometer	0.018***	0.015**	0.020**	0.039**	0.023***
	(0.007)	(0.007)	(0.009)	(0.019)	(0.007)
Mean of Outcome	0.579	0.579	0.579	0.583	0.582
Observations	12,683	12,683	10,151	6,249	9,809
SubmarineCables×Connected, SA-QLFS	0.021***	0.025***	0.018**		0.012*
	(0.007)	(0.008)	(0.007)		(0.007)
Mean of Outcome	0.711	0.711	0.690		0.699
Observations	322,957	322,957	301,443		260,954
SubmarineCables×Connected, SA-NIDS		0.014**	0.013**		0.012*
		(0.007)	(0.006)		(0.006)
Mean of Outcome		0.696	0.693		0.700
Observations		37,558	36,426		30,760
Time FE	Yes	Yes	Yes	Yes	Yes
Grid-cell FE	Yes	Yes	Yes	Yes	Yes

Column 1 removes segments from AfTerFibre (2014)' backbone map that are present in the backbone map from www.africabandwidthmaps.com in 2013/Q2 but not 2009/Q2. Column 2 defines the backbone map as the intersection of AfTerFibre (2014)'s map and www.africabandwidthmaps.com map from 2013/Q2. Column 3 drops observations that lie within a 20 km distance of a landing station. Column 4 drops observations from unconnected locations. Column 5 excludes observations that are either very close to (<10th percentile) or far away (>90th percentile) from the backbone network. Grid-cells are 0.2×0.2 decimal degrees. Individuals (locations) considered connected if within median distance of the backbone network. OLS regressions. Robust standard errors clustered at grid-cell level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE VI: FAST INTERNET AND EMPLOYMENT, INCLUDING PLACEBO "TREATMENTS" FOR ROAD NETWORK, ELECTRICITY GRID, AND 3G COVERAGE, AND CONTROLLING FOR TRENDS

	DHS	Afro-barometer	SA-NIDS	SA-QLFS			
Unit of analysis:	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)
SubmarineCables×Connected	0.017***	0.024***	0.013**	0.015**	0.014**	0.019***	0.014*
	(0.004)	(0.007)	(0.006)	(0.007)	(0.007)	(0.007)	(0.008)
Mean of outcome	0.620	0.579	0.696	0.711	0.711	0.711	0.711
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Grid-cell FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Road and electricity "treatment" controls	Yes	Yes	Yes	Yes	No	No	No
3G "treatment" control	No	No	No	No	Yes	No	No
Linear grid-cell trend	No	No	No	No	No	Yes	No
Connected status x Quarter	No	No	No	No	No	No	Yes
Observations	152,674	12,683	37,558	322,957	322,957	322,957	322,957

Grid-cells are 0.2×0.2 decimal degrees. Individuals (locations) considered connected if within median distance of respectively the backbone network, the road network, the electricity grid, or 3G coverage. The placebo "treatment" controls interact road/electricity/3G connectivity with submarine cable arrival. The second to last column includes a linear trend at grid-cell level. The last column includes a non-linear trend at connected vs unconnected level (by interacting connected status with quarter dummies). OLS regressions. Robust standard errors clustered at grid-cell level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$.

TABLE VII: FAST INTERNET AND EMPLOYMENT IN SKILLED AND UNSKILLED POSITIONS

Panel A: ISCO skill levels

	All skilled	Un-skilled	Highly skilled	Skilled	Moderately skilled	Un-skilled
Unit of analysis:	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)
DHS						
SubmarineCables×Connected	0.032***	-0.022***	0.004**		0.028***	-0.022***
	(0.006)	(0.004)	(0.002)		(0.006)	(0.004)
Mean of Outcome	0.459	0.192	0.0384		0.420	0.192
Observations	152,713	152,678	152,676		152,711	152,678
SA-QLFS						
SubmarineCables×Connected	0.033***	-0.017***	0.016***	0.009**	0.008	-0.017***
	(0.009)	(0.005)	(0.006)	(0.003)	(0.006)	(0.005)
Mean of Outcome	0.489	0.222	0.0844	0.0792	0.3255	0.222
Observations	322,957	322,957	322,957	322,957	322,957	322,957
SA-NIDS						
SubmarineCables x Connected	0.018***	-0.010*	0.008*	-0.000	0.011**	-0.010*
	(0.006)	(0.006)	(0.004)	(0.001)	(0.004)	(0.006)
Mean of Outcome	0.29	0.15	0.073	0.021	0.19	0.15
Observations	37,560	37,560	37,560	37,560	37,560	37,560

Panel B: Occupations

	Profes-sional	Cler-ical	Serv-ices	Dom-estic	Retail/ sales	Empl. agri.	Self-empl. agri.	Unskilled manual	Tech-nical	Elem-entary
Unit of analysis:	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)
DHS										
SubmarineCables×Connected	0.004**	-0.002***	0.002	0.001*	0.020***	0.010***	0.002	-0.024***		
	(0.002)	(0.001)	(0.003)	(0.000)	(0.006)	(0.004)	(0.003)	(0.004)		
Mean of outcome	0.0384	0.00776	0.0595	0.0018	0.246	0.042	0.183	0.007		
Observations	152,676	152,674	152,676	152,674	152,691	152,681	152,677	152,675		
SA-QLFS										
SubmarineCables×Connected	0.007***	0.004	0.002	-0.004					0.009**	-0.013***
	(0.003)	(0.004)	(0.004)	(0.003)					(0.003)	(0.004)
Mean of outcome	0.0347	0.0738	0.0926	0.0564					0.0792	0.161
Observations	322,957	322,957	322,957	322,957					322,957	322,957
SA-NIDS										
SubmarineCables×Connected	0.006	0.002	0.006						-0.001	-0.023**
	(0.003)	(0.004)	(0.004)						(0.003)	(0.010)
Mean of outcome	0.13	0.063	0.15						0.048	0.33
Observations	37,560	37,560	37,560						37,560	37,560
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Grid-cell FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

We categorize occupations' skill level following the ILO's ISCO categorization, and display results for the categories for which we find a significant effect of fast Internet in at least one of the three datasets
For DHS, the highly skilled occupation group (skill level 4) is professional; moderately skilled occupations (skill level 2) include clerical, skilled manufacturing, retail and sales, services and employed agriculture; and unskilled occupations (skill level 1) include unskilled manufacturing, self-employed agriculture, and domestic workers. No employment in skill level 3 is observed in the DHS sample. For QLFS, highly skilled occupations include legislative workers and professionals; skilled occupations (skill level 3) include technical workers; moderately skilled occupations include clerical, skilled agriculture, crafts workers, services, and plant workers; and unskilled occupations include elementary workers and domestic workers. For NIDS, highly skilled occupations include managers and professionals; skilled occupations include technical workers; moderately skilled occupations include services, skilled agriculture, clerical workers, craft workers, and plant and machinery workers; and unskilled occupations include armed forces and elementary workers. "All skilled" corresponds to skill levels 2-4. Grid-cells are 0.2×0.2 decimal degrees. Individuals (locations) considered connected if within median distance of the backbone network. OLS regressions. Robust standard errors clustered at grid-cell level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table VIII: Fast Internet and Employment, and employment in skilled and unskilled positions, by Educational Attainment

	Employed	All skilled	Unskilled	Professional	Clerical	Services	Domestic	Retail/ sales	Empl. agri.	Self-empl. agri.	Unskilled manual	Technical	Elementary
Unit of analysis:	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)
DHS													
SubmarineCables × Connected													
× Not primary	0.014**	0.054***	-0.046***	0.004**	-0.001	0.003	0.000	0.037***	0.015***	-0.022***	-0.025***		
	(0.007)	(0.008)	(0.005)	(0.002)	(0.000)	(0.002)	(0.001)	(0.006)	(0.004)	(0.004)	(0.004)		
× Primary	0.026***	0.053***	-0.027***	0.004***	-0.001**	0.002	0.003***	0.026***	0.022***	-0.008*	-0.022***		
	(0.006)	(0.008)	(0.006)	(0.001)	(0.000)	(0.003)	(0.001)	(0.006)	(0.006)	(0.005)	(0.004)		
× Secondary	0.007	0.018***	-0.012***	0.003*	-0.002**	0.001	0.000	0.015**	0.004	0.013***	-0.025***		
	(0.005)	(0.007)	(0.004)	(0.002)	(0.001)	(0.004)	(0.001)	(0.007)	(0.004)	(0.003)	(0.004)		
× Higher	-0.002	0.014*	-0.015***	0.001	-0.005***	0.006*	-0.001*	0.007	0.007*	0.009***	-0.023***		
	(0.006)	(0.008)	(0.004)	(0.004)	(0.002)	(0.003)	(0.000)	(0.007)	(0.004)	(0.003)	(0.003)		
Observations	152,674	152,713	152,678	152,676	152,674	152,676	152,674	152,691	152,681	152,677	152,675		
Afrobarometer													
SubmarineCables × Connected													
× Not primary	0.029**												
	(0.015)												
× Primary	0.030***												
	(0.009)												
× Secondary	0.019**												
	(0.009)												
× Higher	0.008												
	(0.010)												
Observations	12,218												
SA-QLFS													
SubmarineCables × Connected													
× Not primary	-0.007	-0.003	-0.004	0.002	-0.006*	-0.004	0.008					-0.000	-0.011
	(0.010)	(0.009)	(0.010)	(0.002)	(0.003)	(0.005)	(0.007)					(0.003)	(0.010)
× Primary	0.007	0.012*	-0.006	0.001	0.001	0.001	0.000					0.002	-0.006
	(0.007)	(0.007)	(0.006)	(0.002)	(0.003)	(0.004)	(0.003)					(0.003)	(0.005)
× Secondary	0.025***	0.039***	-0.014***	0.001	0.004	0.004	-0.005*					0.015***	-0.009**
	(0.008)	(0.009)	(0.005)	(0.003)	(0.006)	(0.006)	(0.003)					(0.004)	(0.004)
× Higher	0.010	0.018**	-0.008	0.015*	0.002	0.004	-0.003					-0.026***	-0.005
	(0.008)	(0.009)	(0.005)	(0.008)	(0.006)	(0.006)	(0.003)					(0.010)	(0.004)
Observations	319,592	319,592	319,592	319,592	319,592	319,592	319,592					319,592	319,592
SA-NIDS													
SubmarineCables × Connected													
× Not primary	-0.011	0.006	-0.023	0.001	0.012*	-0.002						0.023*	0.005
	(0.014)	(0.011)	(0.016)	(0.005)	(0.007)	(0.005)						(0.012)	(0.005)
× Primary	-0.002	0.004	-0.015*	0.003	0.009*	-0.000						-0.001	0.002
	(0.009)	(0.008)	(0.009)	(0.005)	(0.005)	(0.003)						(0.009)	(0.004)
× Secondary	0.017***	0.018***	-0.007	0.002	-0.003	0.002						0.009	-0.003
	(0.006)	(0.006)	(0.005)	(0.004)	(0.005)	(0.004)						(0.006)	(0.003)
× Higher	-0.013	0.026	-0.019***	0.030**	-0.003	-0.006						-0.015*	0.002
	(0.011)	(0.018)	(0.007)	(0.013)	(0.021)	(0.011)						(0.009)	(0.010)
Observations	37,516	37,518	37,516	37,516	37,516	37,516						37,516	37,516
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Grid-cell FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Controls for educational attainment (primary school not completed, primary school completed, secondary school completed, and higher education) included. Same occupational categories shown as in Table VII. Grid-cells are 0.2 × 0.2 decimal degrees. Individuals (locations) considered connected if within median distance of the backbone network. OLS regressions. Robust standard errors clustered at grid-cell level in parentheses. $^{***}p < 0.01, ^{**}p < 0.05, ^{*}p < 0.10$

TABLE IX: FAST INTERNET AND EMPLOYMENT, BY GENDER

	Afrobarometer		SA-QLFS		SA-NIDS	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**
Unit of analysis:	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)
SubmarineCables×Connected	0.026***	0.018**	0.012	0.020**	0.011	0.014*
	(0.009)	(0.009)	(0.008)	(0.008)	(0.007)	(0.008)
Mean of Outcome	0.641	0.510	0.746	0.676	0.754	0.646
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Grid-cell FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,395	5,846	163,182	159,775	17,360	20,197

The DHS sample used contains only women and is therefore not shown. Grid-cells are 0.2×0.2 decimal degrees. Individuals (locations) considered connected if within median distance of the backbone network. OLS regressions. Robust standard errors clustered at grid-cell level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE X: FAST INTERNET, FIRM ENTRY AND BUSINESS OWNERSHIP IN SOUTH AFRICA

	SA-CIPC					SA-QLFS
	All firms	**Agri-culture**	**Retail/ sales**	**Tech-nology**	**Manu-facturing**	**Own business**
Unit of analysis:	Firm (Log #)	Firm (Log #)	Firm (Log #)	Firm (Log #)	Firm (Log #)	Individual (0/1)
SubmarineCables×Connected	0.012	0.030**	0.093***	0.040**	0.008	0.003
	(0.037)	(0.015)	(0.036)	(0.020)	(0.012)	(0.002)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes
Grid-cell FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7,909	7,909	7,909	7,909	7,909	556,870

CIPC outcomes are the log of all newly registered firms in a given quarter and zip-code. See the Appendix for information on how firms are categorized into sectors. Sectors not shown here are financial, services, white collar, blue collar, mining, and tourism. The point estimate is positive and insignificant for these sectors. The business ownership indicator form QLFS is equal to one if the individual states that he or she owns a business. Grid-cells are 0.2×0.2 decimal degrees. Firms (locations) considered connected if within median distance of the backbone network. OLS regressions. Robust standard errors clustered at grid-cell level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE XI: FAST INTERNET, EMPLOYMENT, AND PRODUCTIVITY IN ETHIOPIAN FIRMS

Method:	OLS	OLS	OLS	OLS	OLS	Reg LP	Reg LP	Adj LP	Adj LP
	Log(# emplo-) yees)	**Log(# Skilled emplo-) yees)**	**Log(# Unskilled emplo-) yees)**	**Log (value added)**	**Log (value added)**	**Log (value added)**	**Log (value added)**	**Log (value added)**	**Log (value added)**
Unit of analysis:	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm
Submarine Cables × Connected	0.145**	0.139*	0.0822						
	(0.0679)	(0.0744)	(0.0700)						
Capital				0.219***	0.190***	0.444***	0.393***	0.457***	0.399***
				(0.012)	(0.009)	(0.052)	(0.050)	(0.045)	(0.065)
Labor				0.760***		0.290***		0.303***	
				(0.061)		(0.032)		(0.029)	
Unskilled					0.307***		0.109***		0.128***
					(0.057)		(0.032)		(0.033)
Skilled					0.463***		0.204***		0.204***
					(0.026)		(0.017)		(0.017)
Submarine Cables × Connected ×									
Labor				-0.055*		0.005		-0.021	
				(0.033)		(0.010)		(0.018)	
Unskilled					-0.169***		-0.039**		-0.074***
					(0.047)		(0.019)		(0.023)
Skilled					0.081***		0.042***		0.040**
					(0.021)		(0.015)		(0.015)
Control for Productivity				No	No	Yes	Yes	Yes	Yes
Control for Submarine Cables × Connected × Productivity				No	No	No	No	Yes	Yes
Outcome								**Produc-tivity**	**Produc-tivity**
Submarine Cables × Connected								0.146***	0.194***
								(0.048)	(0.044)
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Grid FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	7,672	7,672	7,672	6,226	6,226	6,226	6,226	6,226	6,226

Sample is restricted to firms observed both before and after submarine cable arrival and includes 1,485 distinct firms. Value added is total sales revenue less raw materials and intermediate inputs. Labor is measured as the number of workers employed at the firm. Skilled (unskilled) positions are defined as those earning more (less) than 800 Birr per year, approximately the sample salary median. Capital is the average of start-of-year and end-of-year book value. Production function specifications allow fast Internet to directly affect value added via a change in the intercept (not shown). Grid-cells are 0.2×0.2 decimal degrees. Firms (locations) considered connected if within median distance of the backbone network. OLS regressions. Robust standard errors clustered at grid-cell level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE XII: FAST INTERNET, EMPLOYMENT, AND EXPORTING

	Employment				Trade			Internet use	
	Log(# employees)	**Log(# production employees)**	**Log(# non-production employees)**	**Log (value added)**	**Share national sales**	**Share indirect exports**	**Share direct exports**	**Communicates with email**	**Communicates with website**
Unit of analysis:	Firm	Firm	Firm	Firm	Firm	Firm	Firm	Firm (0/1)	Firm (0/1)
SubmarineCables × Connected	-0.002	0.032	0.073**	0.152	-0.021**	0.006	0.016**	0.013	0.022*
	(0.022)	(0.034)	(0.034)	(0.268)	(0.009)	(0.005)	(0.007)	(0.014)	(0.011)
Mean of Outcome					0.965	0.008	0.026	0.370	0.120
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Grid FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,591	4,223	4,202	3,328	6,388	6,400	6,421	6,765	6,759

Value added is defined as a firm's sales net intermediate inputs. The take-up variables are equal to one if the firm states that it is using email or their website to communicate with clients. Indirect exports are defined as going through a third party. Grid-cells are 0.2×0.2 decimal degrees. Firms (locations) considered connected if within median distance of the backbone network. OLS regressions. Robust standard errors clustered at grid-cell level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

TABLE XIII: FAST INTERNET, INCOMES, AND COMPUTER LITERACY

	All 14 countries	SA-NIDS			
	Log (light density)	**Log (income)**	**No computer literacy**	**Basic computer literacy**	**High computer literacy**
Unit of analysis:	Grid-cell	Individual	Individual (0/1)	Individual (0/1)	Individual (0/1)
SubmarineCables × Connected	0.020***	0.050**	-0.025***	0.013***	0.012***
	(0.001)	(0.026)	(0.006)	(0.004)	(0.004)
Mean of outcome			0.707	0.193	0.1000
Time FE	Yes	Yes	Yes	Yes	Yes
Grid-cell FE	Yes	Yes	Yes	Yes	Yes
Observations	128,807	16,817	71,165	71,165	71,165

Column 1 estimates the effect of fast Internet on light density at night at yearly level. The second column uses data from NIDS and estimates the effect of fast Internet on individuals' log gross income, measured in South African Rands. This variable is only available for employed individuals and has missing values, which explains the lower number of observations, compared to the other outcomes. No, basic, and high computer literacy are indicator variables. Grid-cells are 0.2×0.2 decimal degrees. Individuals (locations) considered connected if within median distance of the backbone network. OLS regressions. Robust standard errors clustered at grid-cell level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

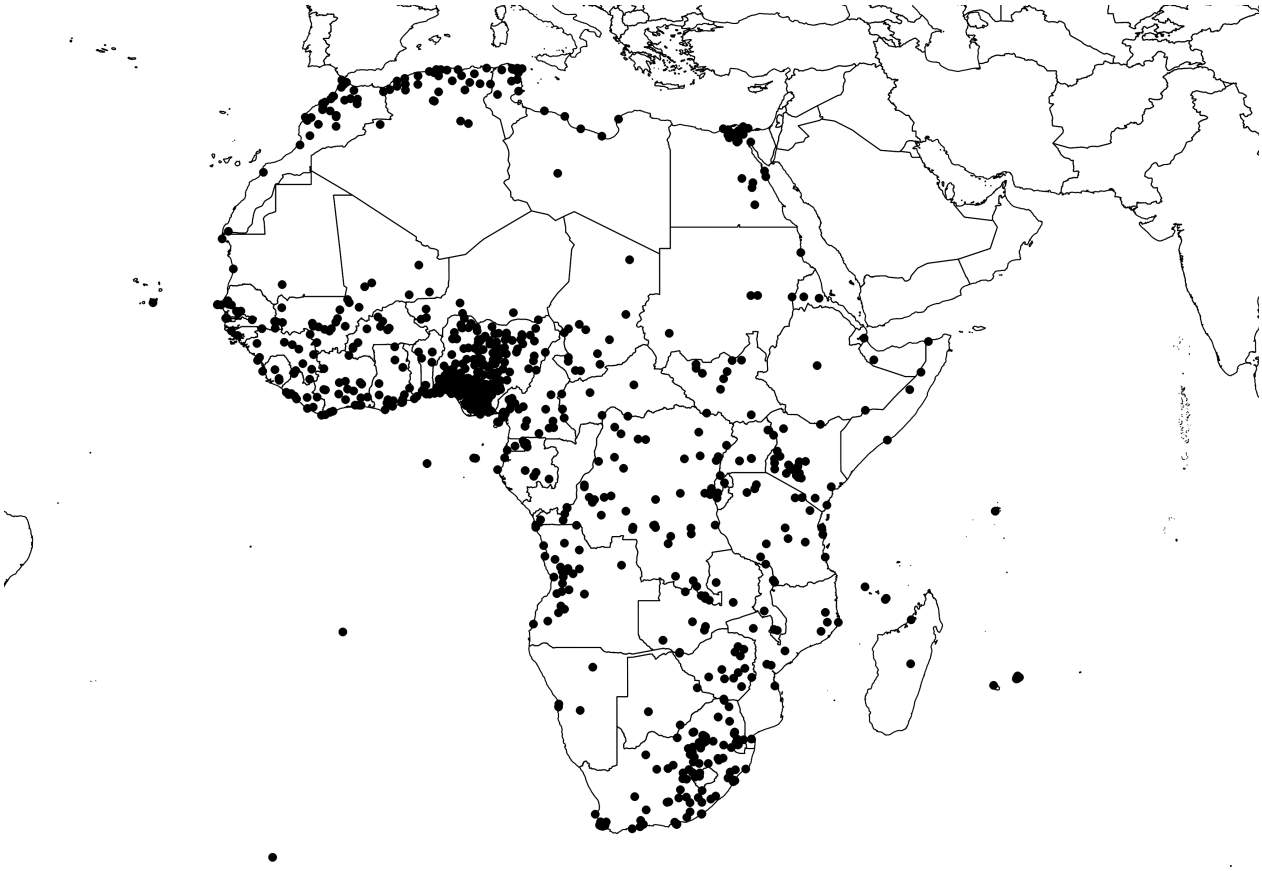
Appendix

The South Africa Companies and Intellectual Property Commission's administrative dataset of firm registrations categorizes firms only as public, private or NGO. To estimate the effect of fast Internet on sector specific firm creation, we thus need to categorize the firms based on their names. We choose a set of sectors that, as far as possible, correspond to the categories of occupations reported in the DHS, QLFS and NIDS datasets: services, white collar firms, blue collar firms, retail and sales, technology, manufacturing, finance, agriculture, mining, and tourism and foods.

We start by splitting all firm names on the space between the words. For example, "The South African Mining Company" would render five new variables. The first one would be called "name1" and would have the value "The", the second one would be called "name2" and would have the value "South", and so on.

name2, as specified above, usually contains the important key word that makes it possible to categorize a firm, such as "accounting", "trading", "properties", or "catering". We therefore use name2 to manually match key words to the sectors listed above. For example, we categorize firm X as belonging to the technological sector if name2 contains the words "computer", "tech", "telecommunications", and so on. The mapping of words to sectors is provided in Appendix Table A3. Of course, the key words could have ended up in any of the other name variables. We thus run the exact same iteration for all of those, up to name10. With this method, we are able to categorize 67 percent of the firms in the CIPC sample.

FIGURE A1: LOCATIONS INCLUDED IN DATASET ON INTERNET SPEEDS



This graph plots the locations for which Akamai has information on Internet speed between 2007 and 2014. There are around 920 locations in this sample.

TABLE A1: FAST INTERNET AND EMPLOYMENT, LEADS AND LAGS IN THE TIMING OF SUBMARINE CABLE ARRIVAL

	SA-QLFS		
Unit of analysis:	Individual (0/1)	Individual (0/1)	Individual (0/1)
Quarters since cable arrival:			
1	0.016**		
	(0.008)		
0	0.001	0.016**	0.018**
	(0.006)	(0.007)	(0.008)
-1			-0.002
			(0.005)
Mean of Outcome	0.711	0.711	0.711
Time FE	Yes	Yes	Yes
Grid-cell FE	Yes	Yes	Yes
Observations	322,957	322,957	322,957

This table shows the effect of submarine cable arrival at different points in time. The estimates come from running separate regressions with the main treatment variable as well as a lead or a lag. Grid-cells are 0.2×0.2 decimal degrees. Individuals (locations) considered connected if within median distance of the backbone network. OLS regressions. Robust standard errors clustered at grid-cell level in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Table A2: Employment in skilled and unskilled occupations by Educational Attainment before fast Internet arrival

	Employed	All skilled	Unskilled	Professional	Clerical	Services	Domestic	Retail/ sales	Empl. agri.	Self-empl. agri.	Unskilled manual	Technical	Elementary
Unit of analysis:	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)	Individual (0/1)
DHS													
Not primary	0.68	0.42	0.30	0.0055	0.00017	0.031	0.0020	0.28	0.038	0.298	0.003		
Primary	0.65	0.46	0.22	0.015	0.0014	0.065	0.0026	0.25	0.058	0.205	0.01		
Secondary	0.50	0.47	0.046	0.055	0.016	0.095	0.00084	0.21	0.037	0.035	0.01		
Higher	0.62	0.62	0.012	0.33	0.057	0.043	0.00065	0.15	0.008	0.0026	0.01		
Afrobarometer													
Not primary	0.46												
Primary	0.54												
Secondary	0.66												
Higher	0.79												
SA-QLFS													
Not primary	0.72	0.26	0.44	0.0019	0.0067	0.056	0.14					0.014	0.31
Primary	0.65	0.38	0.27	0.0089	0.040	0.092	0.071					0.028	0.20
Secondary	0.70	0.59	0.11	0.032	0.15	0.13	0.018					0.079	0.096
Higher	0.91	0.89	0.022	0.18	0.12	0.063	0.0017					0.32	0.020
SA-NIDS													
Not primary	0.78	0.10	0.27	0	0	0.01						0.001	0.27
Primary	0.71	0.16	0.24	0.002	0.003	0.03						0.007	0.25
Secondary	0.64	0.33	0.10	0.06	0.04	0.08						0.03	0.10
Higher	0.95	0.79	0	0.16	0.06	0.05						0.05	0

This table displays the probability of employment in different occupations for individuals of varying educational attainment prior to fast Internet arrival.

TABLE A3: CATEGORIZATION OF SOUTH AFRICAN FIRMS' SECTOR BASED ON KEY WORDS FROM FIRM NAMES

Services:									
abbatoir	accommodation	acquisitions	advertising	air-conditioning	aircon	airconditioning	airlines	airport	answers
apartments	art	arts	assessing	assessment	assessments	assist	assistance	aviation	baby
bakery	bar	bars	bay	bistro	block	booking	boxing	burial	cafe
care	carriers	carwash	caterers	catering	caterings	chauffeur	child	children	childrens
christian	church	clinic	clinical	clinics	club	coaches	coaching	coffee	coffees
college	commercial	communication	communications	compliance	concerts	conditioning	conference	conferences	consultation
cooking	cosmetics	cottages	council	counsellors	courier	couriers	couture	creche	cuisine
cure	dance	daycare	deliveries	design	designs	destination	destinations	dienste	driver
driving	drycleaners	eatery	eats	educare	education	empowerment	entertainment	estate	estates
event	events	exhibitions	export	exporters	exporting	exports	facilitators	fashion	fast
feed	fellowship	fencing	fitness	flats	food	football	franchising	funeral	funerals
games	gaming	gardening	god	gourmet	guest	guesthouse	gym	habitat	hair
hairdresser	haven	healing	health	healthcare	hire	hiring	homecare	homecleaners	homes
homestead	hospital	hospitality	host	hosting	hotel	hotels	house	housing	immobiliare
implementation	import	importers	imports	information	innovations	inspections	installations	intelligence	islam
kafee	karate	kontrakteurs	laundry	leadership	learning	leasing	leisure	living	lodge
logistic	logistics	logistix	mail	makelaars	mansions	meals	memorials	migration	ministries
ministry	mission	missions	monitoring	motel	networking	nominees	nursery	nursing	orchards
outsource	paintball	park	parking	payment	payments	pet	planning	pools	pre-school
procurement	promotions	properties	property	protection	realty	recruit	recruiting	recruitment	recruits
recycling	rent	rental	rentals	residence	residential	residentials	resourcing	restaurant	restaurants
resturant	resturants	retirement	retreat	rugby	safety	salon	sanctuary	school	security
seminars	service	services	servicing	shaving	shipping	shuttle	shuttles	spa	sport
sports	sportsbar	staffing	storage	strategies	strategy	supervision	surgical	swimming	tavern
tax	taxi	theatre	theatres	tourism	tours	training	tranport	transformation	transformers
transport	transportation	transporters	transporting	travel	traveling	travelling	travels	treats	trucking
tutoring	undertakers	venue	villa	village	villages	villas	wash	waste	wedding
weddings	wellbeing	wellness							
White collar:									
academy	admin	administrasie	administration	administrators	advisors	advisory	akademie	analytics	architechts
architects	architectura	architectural	architecture	assurance	attorneys	biometrics	branding	chemical	chemicals
consult	consultancies	consultancy	consultant	consultants	consulting	data	decor	dental	designers
directors	editing	entrepreneurs	fashions	forensic	forensics	geoconsultants	ideas	institute	insurance
interior	interiors	konsultante	landscaping	legal	management	managers	managing	marketing	media
optometrist	optometrists	petrochemicals	publication	publishers	publishing	publishings	radiology	research	risk
translation									
Blue collar:									
autobody	automobile	baking	blocks	brick	brickforce	bricks	build	builders	building
butchery	car	carpenter	carpentry	clean	cleaners	cleaning	coaters	coating	coatings
concrete	construction	constructions	constructors	contracting	contractors	deco	distribution	distributions	distributor
distributors	drilling	equipment	fabrics	filtration	fishing	flooring	forestry	foundry	freight
fuel	gas	hunters	hunting	installation	installations	irrigation	knitting	konstruksie	laminations
lawns	maintenance	mechanics	metal	metals	movers	packaging	packing	paint	painters
painting	paints	pavers	paving	plastering	plumbers	plumbing	recyclers	refrigiration	refurbishing
renovations	repair	repairs	roofing	scaffolding	textiles	towing	truck	woodwork	
Retail and sales:									
accessories	aesthetics	affairs	alarms	apparel	appliances	auction	auctioneers	auctions	auto
bags	bathrooms	beads	beautique	beauty	bedding	beverages	books	booksellers	bookshop
boutique	brand	brands	bread	canopies	cement	ceramics	cheese	clothing	commerce
commodities	components	condoms	confectionary	confectionery	consumables	cooling	cosmetic	cosmetics	covers
crafts	creations	cupboards	curtain	curtains	dealer	dealers	deals	delights	detailing
diary	discounters	elegance	enterprise	enterprises	fertilisers	films	flowers	foods	footwear
fuels	furnishers	furniture	furnitures	garden	garments	gift	gifting	gifts	glass
goodies	goods	groceries	grocery	handelaars	hardware	heating	herbs	hygiene	images
ingredients	instruments	jewellers	jewellery	juice	kiosk	kitchen	kitchens	kitchenware	leather
lifestyle	lighting	lights	linen	liquor	liquors	lubricants	machinery	machines	mall
market	markets	mart	materials	meat	meats	medical	medicine	merchandise	merchandising
merchant	mini-supermarket	motor	motorcycles	motors	movies	music	newspaper	noodles	nutrition
oil	oils	optical	opticals	outdoor	outfitter	outfitters	parts	patisserie	pawn
pearls	perfumes	petroleum	pharmaceutica	pharmaceutical	pharmaceuticals	pharmacy	photography	photos	pictures
plant	plants	plates	print	printers	printing	printings	prints	produce	pumps
refrigeration	remedies	resale	retail	retailers	retailing	sales	sewing	shoes	shop
shopfitters	shopping	signs	snacks	spices	sportswear	stationary	stationers	stationery	store
style	suit	superette	supermarket	superstore	supplements	supplier	suppliers	supplies	supply
sweets	telesales	things	timber	timbers	toiletries	tools	towels	toys	trailers
tyre	tyres	upholsterers	upholstery	vehicle	vehicles	vending	wear	wholesailers	wholesale
wholesaler	wholesalers	windscreen	windscreens	wine	wines				
Technology:									
3d	apps	audio	cable	cables	cabling	cellular	computer	computers	computing
digital	electrical	electricals	electrician	electricians	electronics	energy	engeneering	engineering	engineers
fibre	hydraulics	infrastructure	internet	it	mechanical	mobile	multimedia	online	software
solar	tech	technical	technicians	technics	technik	technique	techniques	technological	technologies
technology	telecommunication	telecommunications	telecoms	web	website				
Manufacturing:									
brewery	brewing	fabrication	factory	manufacturer	manufacturers	manufactures	manufacturing	plastic	plastics
production	productions	products	refineries	refiners	refinery	refining			
Financial:									
accountant	accountants	accounting	asset	audit	auditors	beleggings	bonds	bookkeeping	brokers
capital	cash	clearing	credit	credits	debt	equities	equity	finance	finances
financial	finans	finansiele	fund	funding	futures	holding	holdings	invest	investements
investing	investment	investments	investors	lending	loan	loans	money	mortgage	mortgages
portfolio	portfolios	savings	securities	trade	traders	trading	tradings	trust	wealth
Agriculture:									
agri	agri-business	agribusiness	agricultural	agriculture	boerdery	boerderye	farm	farmers	farming
farms	fisheries	growers	horticultural	horticulture	livestock	poultry			
Mining:									
alu	aluminium	aluminum	coal	copper	diamond	diamonds	gold	iron	mine
mineral	minerals	mines	mining	platinum	steel	steelworks	uranium		
Tourism and foods:									
bagel	burgers	cakes	chicken	chickens	cookies	fish	fruit	fruits	pizza
resort	resorts	safari	safari's	safaris	tour	vacations			

This table displays the key words used when assigning firms observed in the CIPC data to a sector. See the Appendix for details on the procedure.