Economic Impacts of Submarine Fiber Optic Cables and Broadband Connectivity in Mozambique

Working Paper 0214363.202.3

November 2020

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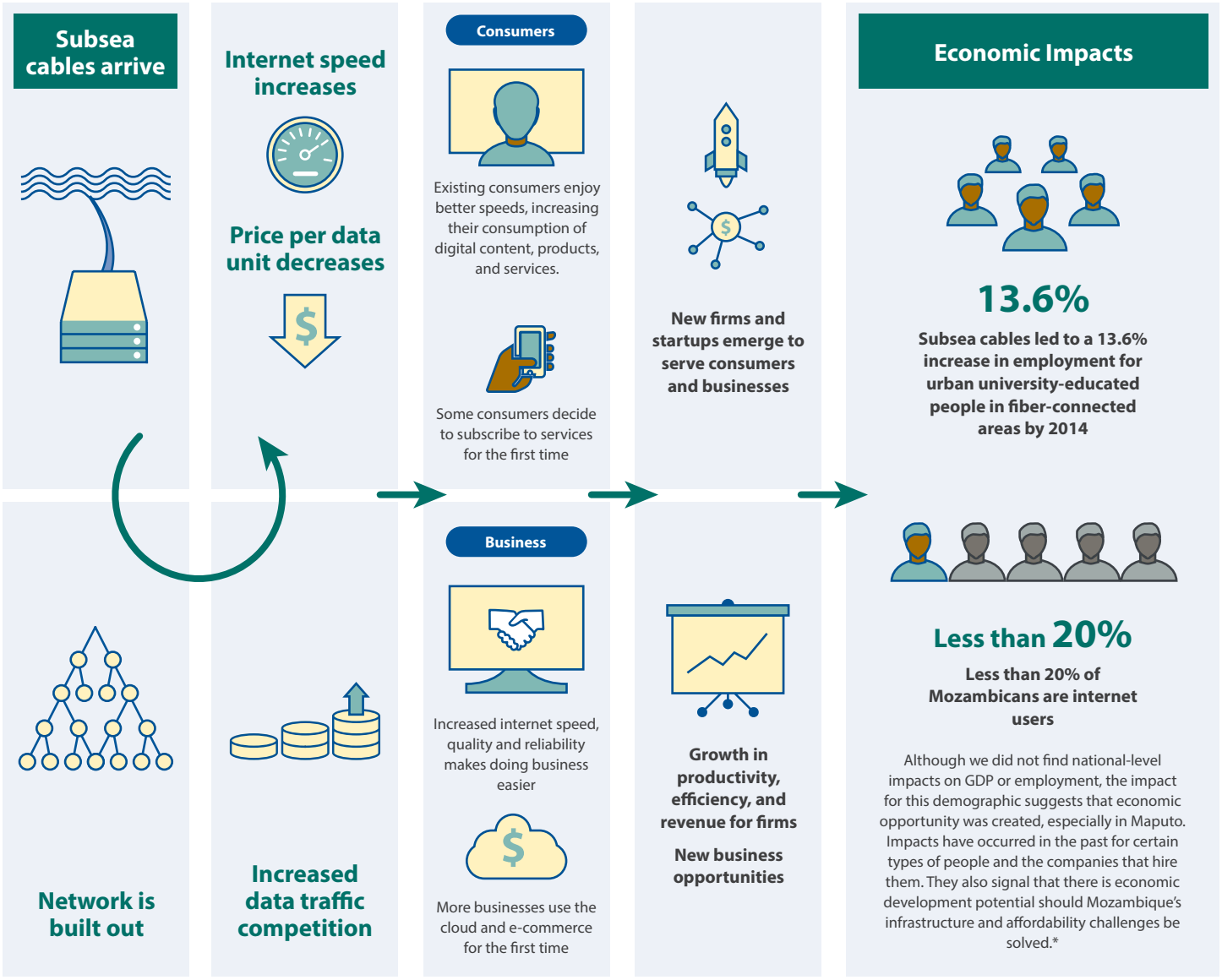
HOW DO SUBSEA CABLES GENERATE ECONOMIC IMPACT?

Subsea cables are the global backbone of the Internet, connecting people, businesses, and economies around the world. They connect us to the cloud, deliver streaming video, and increase efficiency and productivity for business. Subsea cables' importance is all the more apparent during the Covid19 pandemic when many of us have switched to working from home, remote learning, and online gaming and entertainment.

We studied the economic impacts from subsea cables that arrived in Kenya in Mozambique (e.g., SEACOM, EASSy) to understand how they changed the economy. Improved connectivity led to increases in internet usage and decreases in costs, but infrastructure and affordability challenges meant that impacts were mostly in the Maputo area by 2015. Our results signal the promise connectivity improvements could have in other parts of the country.



* We interviewed 14 Mozambican experts in broadband connectivity. They described the challenges that Mozambique experiences with infrastructure overall, not just for internet connectivity, and the difficulties in generating economies of scale. They also note that data traffic is expensive to carry out of Maputo, largely because there is distance pricing for data that makes service many times more expensive in the north of the country than in Maputo in the far south.

Download the full report at rti.org/subsea-cables-africa

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Recommended Citation: O'Connor, A.C., B. Anderson, F. Mabila, S.E. Lawrence, and A.O. Brower. 2020, November. Economic Impacts of Submarine Fiber Optic Cables and Broadband Connectivity in Mozambique. Working Paper 0214363.202.3. Research Triangle Park, NC, USA: RTI International.

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Recommended Citation: O'Connor, A.C., B. Anderson, F. Mabila, S.E. Lawrence, and A.O. Brower. 2020, November. *Economic Impacts of Submarine Fiber Optic Cables and Broadband Connectivity in Mozambique*. Working Paper 0214363.202.3. Research Triangle Park, NC, USA: RTI International.

1. Overview

This study explores the economic impact of the international data connectivity delivered by submarine fiber optic cables ("subsea cables") on Mozambique. Subsea cables are the global backbone of the internet, connecting people, businesses, and economies around the world.[1,2]

The importance of connectivity to economic growth is well-established—and further underscored by our collective experience during the COVID-19 pandemic—but rigorous studies have not been conducted for many countries.[3,4,5] This study is one in a series our team prepared about how improvements in international data connectivity have generated economic growth for countries in Africa.[6]

For Mozambique, a nation of 30 million people on Africa's east coast, we focus on two recent cable landings, SEACOM and EASSy. Subsea cables connect the domestic terrestrial fiber network to cloud services and data resources around the world (Figure 1). The more robust the connection between the user and the data resource, the faster, better, and more productive is their user experience. Poor connections render some services unusable.

Following the landing of SEACOM, the most significant subsea cable for Mozambique, telecommunications experts interviewed for this work described substantial improvements in the cost, speed, and quality of internet service. Despite this, only about 21% of Mozambicans are internet users. Mozambique is characterized by poor access to electricity and illiteracy rates that impede uptake.

Our analysis found that, by 2014, people who are university educated, live in cities, and are within a few hundred meters of fiber infrastructure are 13.6% more likely to be employed. Although we did not find national-level impacts on GDP or employment, the impact for this demographic suggests that economic opportunity was created, especially in Maputo. The results signal that impacts have occurred in the past for certain types of people and the companies that hire them. They also signal that there is economic development potential should infrastructure and affordability challenges be solved.

We interviewed 14 Mozambican experts in broadband connectivity. They described the challenges that Mozambique experiences with infrastructure overall, not just for internet connectivity, and the difficulties in generating economies of scale. They also note that data traffic is expensive to carry out of Maputo, largely because there is distance pricing for data that makes service many times more expensive in the north of the country than in Maputo in the far south.

This paper reviews our economic analysis findings, complemented by perspectives from experts in the Mozambican internet ecosystem.

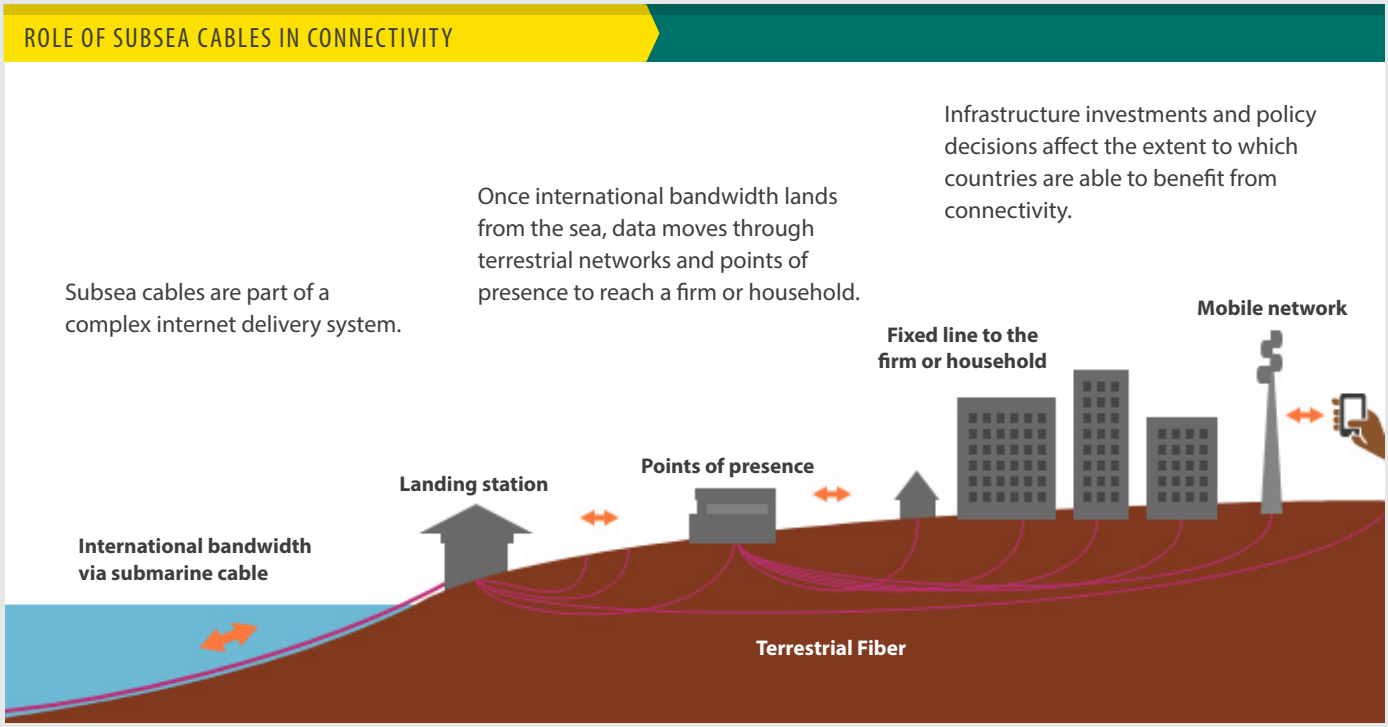
Table 1. Key Takeaways: The Economic Impact of Subsea Cables on Mozambique

INDICATOR	TIME PERIOD	OUTCOME
Employment	2009—2014	13.6% increase in employment for urban university-educated people who live within a few hundred meters of the terrestrial fiber infrastructure

Source: Authors' estimates.

1 Clark, K. 2019. *Submarine Telecoms Industry Report, 7th Edition*. Submarine Telecoms Forum.
2 Brake, D. 2019. *Submarine Cables: Critical Infrastructure for Global Communications.* Information and Technology Foundation.
3 Hjort, J, Poulsen, J. 2019. The Arrival of Fast Internet and Employment in Africa. *American Economic Review*, 109(3): 1032-1079.
4 Minges, M. 2015. Exploring the Relationship between Broadband and Economic Growth. WDR 2016 Background Paper; World Bank, Washington, DC.
5 Khalil, M., Dongier, P., & Zhen-Wei Qiang, C. 2009. *Information and Communications for Development: Extending Reach and Increasing Impact*. World Bank.
6 Other countries included in this series are the Democratic Republic of Congo, Kenya, Nigeria, South Africa, and Tanzania.

Figure 1. **Role of Subsea Cables in Internet Connectivity**



2. Mozambique Country Profile

Mozambique stretches along the East Africa coast between South Africa and Tanzania. In 2019, its gross domestic product (GDP)—the most common measure of the total value of all goods and services produced by a country—was $14.9 billion (nominal terms). With a population of just over 30 million people, this translates into a GDP per capita of $492.

Mozambique's GDP grew by 3.4% in 2018.[7] Growth has been hampered in recent years because of tropical cyclones that caused extensive damage to livelihoods and infrastructure. This damage has compounded transportation and telecommunications challenges in many parts of the country where the state of infrastructure was already inadequate. While cities have electricity, most of rural Mozambique does not. Growth has gradually improved, but challenges with infrastructure and debt management remain drags on its economic performance.[8]

In 2017, Mozambique accounted for 17% of global lignite exports, making it the 3rd largest exporter of lignite in the world.[9] Other important exports are coal briquettes and aluminum. The country's informal economy was estimated to be about 30% of GDP between 2010-14.[10] Informal smallholder agriculture and unregistered commerce are common forms of informal economic activity.

Another way to look at Mozambique's GDP is to take into consideration purchasing power parity (PPP). PPP accounts for differing price levels for comparable expenditure categories between countries. By applying PPP one can assess, both

7 World Bank Group. 2019 World Development Indicators. See https://databank.worldbank.org/source/world-development-indicators.
8 World Bank Group. The World Bank in Mozambique. Washington, D.C.: World Bank Group.
9 Simoes, AJG and CA Hidalgo. 2011. *The Economic Complexity Observatory: An Analytical Tool for Understanding the Dynamics of Economic Development*. Workshops at the Twenty-Fifth AAAI Conference on Artificial Intelligence. Data retrieved December 2019. https://oec.world/en/profile/hs92/2709/.
10 International Monetary Fund. 2017. *Regional Economic Outlook: Sub-Saharan Africa, Restarting the Growth Engine*. Washington D.C.: International Monetary Fund.

Table 2. **Key Indicators for Mozambique's Population and Economy**

INDICATOR		VALUE	YEAR
Population		30.4 million people	2019[a]
Literacy Rate		61% of population aged 15+	2017[b]
Primary education completing rate		36% of population aged 25+	2015[b]
Poverty rate		62% of population below WB poverty line of 1.90 USD PPP/day	2014[b]
GDP, nominal	• Total • Per capita	14.93 billion USD 492 USD	2019[a]
GDP, purchasing power parity	• Total • Per capita	32,676 million (2011 USD PPP) 1,101 (2011 USD PPP)	2017[a]

Sources: [a]Penn World Table and [b]World Bank.

between countries and over time, real year-on-year changes and economic trends based on actual living standards.

Through the lens of PPP, Mozambique's economy is the equivalent of $32.7 billion with a per capita GDP of $1,101. Later, we will use the PPP method of quantifying the Mozambican economy to generate our results, enabling impacts to be interpreted directly as improvements in living standards relative to different points in the past.

Mozambique is currently connected to two subsea cables that landed in 2009 and 2010. Telecomunicações de Moçambique (TDM), now part of Mozambique Telecom (Tmcel), is the primarily state-owned firm which has majority control over access to Mozambique's subsea cable landings. A domestic cable link between Maputo and the central coast city of Beira exists, but is understood to be damaged and is currently not working. Facebook has announced plans to land 2Africa in Mozambique in 2023 or early 2024.

Table 3. **Subsea Cable Landings in Mozambique**

CABLE	DESIGN CAPACITY (TBPS)	LOCAL LANDING STATION(S)	READY FOR SERVICE YEAR
SEACOM/Tata TGN-Eurasia	4.2	Maputo	2009
Eastern Africa Submarine Cable System (EASSy)	11.8	Maputo	2010
2Africa (announced)	180	Maputo	2023

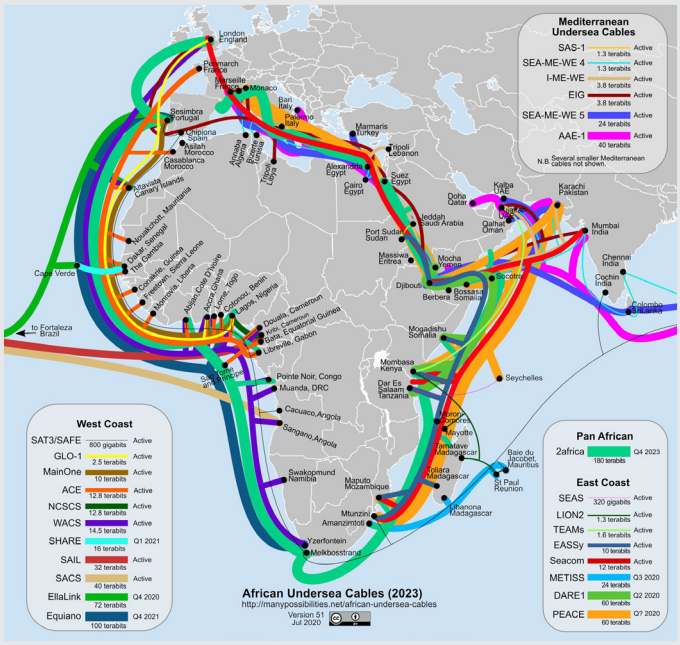
Source: Telegeography's Submarine Cable Map and STF Analytics' Submarine Cable Almanac.

3. Analysis Approach

We analyzed the economic impacts of subsea cables by pairing rigorous economic analysis approaches with interviews with internet connectivity experts in Mozambique. In so doing, not only were we able to understand what the impacts have been of past improvements in connectivity, but also the implications of (and barriers and facilitators to) improvements in connectivity going forward. This section offers a high-level description of our approaches.[11]

Because terrestrial fiber and wireless networks connect users to subsea cables' landing stations, we include them in the analysis. However, we emphasize that the impacts quantified are for the international connectivity associated with cables and not domestic connectivity. Increasingly, nationally hosted internet exchanges, local content delivery networks, and data centers are bringing data resources on shore. Despite this trend, for many emerging economies like Mozambique, most cloud services and data resources accessed domestically are stored abroad. This makes international connectivity critical.

Figure 2. African Undersea Cables



Song, S. 2020. African Undersea Cables (2023). See https//www.manypossibilities.net.

3.1 ECONOMETRIC ANALYSES

We employed two complementary econometric methods: difference-in-differences and synthetic control. Of all available econometric methods and strategies, these two offer the most robust, reliable, and accurate way to estimate causal effects in the context of subsea cables. Each one derives from cutting-edge statistical techniques[12,13,14] and have been used to investigate research questions similar to those posed by our analysis.[15,16]

3.1.1 Difference-in-Differences (DID)

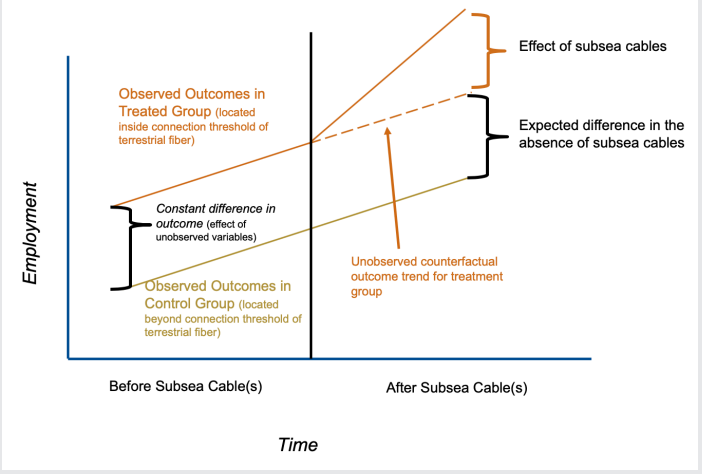
DID estimates the causal impact of subsea cables on employment and firm-level outcomes. DID consists of identifying the impacts associated with a specific intervention or treatment over a period of time. In this analysis, subsea cables (and increases in international data connectivity) are the intervention. The impact ("treatment effect") is identified by comparing the difference in outcomes before and after the intervention for the group exposed to the intervention ("the treatment group") to the same difference for the unexposed ("the control group").

In our approach, assignment to the treatment group is based on close proximity to terrestrial fiber in the base period. Being located near terrestrial fiber is a key factor that would enable individuals/firms to access the benefits of subsea cables. Because DID estimation is based on the differences in the changes that occurred between the two groups pre- and post-subsea cables, the technique inherently controls for many time-invariant factors such as age and gender. See Figure 3.

The data we used for our analysis of employment comes from the United States Agency for International Development's (USAID) Demographic and Health Surveys (DHS),[18] which ask individuals about their employment status and type of

11 A detailed technical addendum accompanies this report.
12 Athey, S., Imbens, G. W. 2017. The State of Applied Econometrics: Causality and Policy Evaluation. *Journal of Economic Perspectives*, 31(2): 3-32.
13 Baum-Snow, N, Ferreira, F. 2017. Causal Inference in Urban and Regional Economics. National Bureau of Economic Research (NBER) Working Paper Series. Working Paper 20535.
14 Imbens, G. W., & Wooldridge, J. M. 2009. Recent developments in the econometrics of program evaluation. *Journal of Economic Literature*, 47(1), 5-86.
15 Hjort, J, Poulsen, J. 2019. The Arrival of Fast Internet and Employment in Africa. *American Economic Review*, 109(3): 1032-1079.
16 Abadie, A., Diamond, A., Hainmueller, J. 2010. Synthetic control methods for comparative case studies: Estimating the effect of California's tobacco control program. *Journal of the American Statistical Association*, 105.490 (2010): 493-505.
17 We use the baseline terrestrial fiber to assign treatment to avoid upward biasing the estimates. Note that the expansion of terrestrial fiber between baseline and endline only makes the estimates more conservative.
18 U.S. Agency for International Development. Demographic and Health Surveys. See https://dhsprogram.com/Data/.

Figure 3. Difference in Differences Technique for Analysis of the Impact of Subsea Cables



occupation. The data for our analysis of firm outcomes come from the World Bank's Enterprise Surveys (WBES).[19] The DHS data are geocoded, which enabled greater precision in our econometric approach than the less spatially explicit WBES data (which identify the location of firms down to the city level).

Using the DHS data, we were able to compare changes in employment outcomes (before and after subsea cables) for individuals located within a few hundred meters of the terrestrial fiber to the same changes for individuals located just beyond this distance but still located within a few kilometers of the fiber. Excluding individuals located farther than a few kilometers from terrestrial fiber and focusing on changes between groups located just on either side of a narrow margin produces a control group with high comparability to the treatment group. The resulting groups are similar in terms of both demographic and geographic characteristics, and they would arguably be subject to the same circumstances, with the exception of subsea cables. Essentially, the only aspect differentiating individuals in the treatment group from members of the control group is that individuals in the treatment group may have much greater potential to access (or benefit from) high-speed internet after subsea cables arrive. Applying DID in this way enables us to tease out the effect of subsea cables from various potential confounding factors such as distance to other infrastructure and arguably any other shocks that may affect employment status.[20]

Because the firm-level data from WBES are spatially aggregated at the city level, we were unable to achieve the same level of specificity for firms as for individuals. For example, with a small number of cities, within which all firms are either assigned to the treatment or the control group (based on whether the city is connected to the terrestrial fiber in the baseline period), it is conceivable that an event unrelated to the arrival of subsea cables affected the outcomes of a large share of firms in one group but not the other (e.g. municipal policy changes). Therefore, we regard the impacts on firms using our DID approach as suggestive.

3.1.2 Synthetic Control (SC)

SC estimates the impact of subsea cables on economic outcomes by comparing Mozambique's actual outcomes after subsea cable arrivals to a model of Mozambique in which the cables did not arrive but for which all other prevailing economic trends continued. This latter version of Mozambique is referred to as a synthetic counterfactual.

The synthetic counterfactual is a weighted combination of similar countries which did not receive subsea cable landings during the time period of interest and that is calibrated to Mozambique's pre-cable arrival state. We use a weighted combination of multiple countries because the resulting counterfactual is more like Mozambique across a variety of important and relevant dimensions than any single comparison country alone. Key dimensions include GDP per capita, labor composition by industry sector, and the proportion of people living in urban areas.

The construction of the counterfactual is completely computationally driven and optimizes its fit based on the countries' actual data. Importantly, the counterfactual can be tested for its robustness and reliability, which helps assess confidence in each set of results. See Figure 4.

The country-level data we used for SC analysis come from the Penn World Table (PWT)[21] and the World Bank's World Development Indicators (WDI).[22] These sources provide relevant national statistics from officially recognized sources,

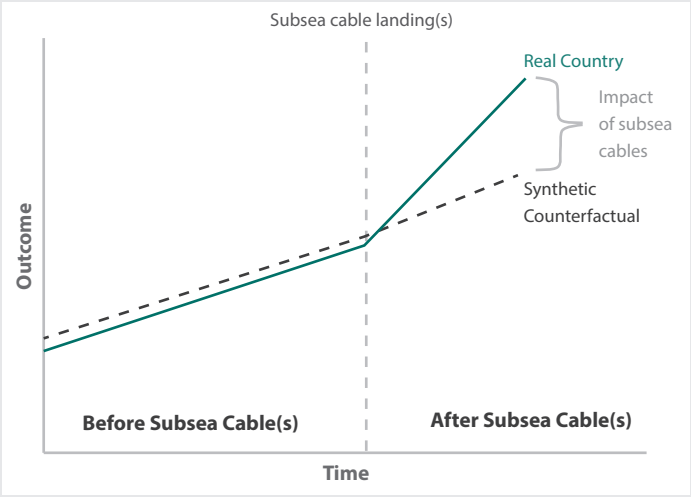
19 World Bank Group. 2019. Enterprise Surveys. See https://www.enterprisesurveys.org/.

20 Many things affect employment status, but factors that would bias the DID estimates are events that occurred between the baseline and endline surveys that differentially affected the outcomes of the two groups. Based on the method of treatment assignment, it is highly unlikely that an event systematically affecting employment outcomes for one group but not the other occurred between the two periods, besides the addition of subsea cables.

21 Feenstra, R. C., Inklaar, R., Timmer, M. 2015. The Next Generation of the Penn World Table. *American Economic Review,* 105(10), 3150-3182.

22 World Bank Group. 2019 World Development Indicators. See https://databank.worldbank.org/source/world-development-indicators.

Figure 4. Synthetic Control Technique for Analysis of Subsea Cables



which are then standardized using a well-documented methodology. Importantly, the detailed methodology and data quality control measures used to standardize the data enable comparison across countries and over time, and thus for our application of SC to match on a variety of important macroeconomic characteristics and outcomes.

The estimated effects using DID and SC provide complementary insights due to their similarities and differences across different dimensions, as described in Table 4. By applying two econometric methods, as well as qualitative interviews, our work provides insight into various aspects of economic impact caused by subsea cable landings.

3.2 THEMATIC ANALYSIS OF INTERVIEWS WITH KEY STAKEHOLDERS

We interviewed 14 Mozambican broadband connectivity experts with telecommunications firms, research entities, and government agencies. Interview topics included current connectivity trends and challenges (e.g., network expansion, latency, affordability), public-sector priorities driving network expansion, role of subsea cables in the broader landscape of connectivity and internet quality, role of connectivity in economic development, and future trends and issues. So that interviewees could be open and candid, we advised that participation could be confidential, that we would not attribute responses to individuals, and that only the synthesized remarks of all interviewees would be presented in our reports.

Table 4. Similarities and Differences of Econometric Analysis Strategies

IMPACT DIMENSION		DIFFERENCE IN DIFFERENCES	SYNTHETIC CONTROL
Treatment	Subsea cables (explicitly)	●	●
Temporality	Discrete point-in-time impacts	●	●
Outcome	Employment	●	●
	Economic growth	●	●
Space	Spatially-specific impacts (specific to fiber-connected areas)	●	
	Spatially-inspecific impacts (at the country-level)		●
Data aggregation	Microdata geocoded to identify individuals/firms in fiber-connected/unconnected areas within countries	●	
	Macrodata on countries (national statistics)		●

24 Feenstra, R. C., Inklaar, R., Timmer, M. 2015. The Next Generation of the Penn World Table. *American Economic Review,* 105(10), 3150-3182.
25 World Bank Group. 2019 World Development Indicators. See https://databank.worldbank.org/source/world-development-indicators.

4. Economic Impacts of Subsea Cable Landings

While there are people across Mozambique enjoying improvements in connectivity overall, our economic analysis found that those who have either directly or indirectly been able to leverage that connectivity into economic opportunity are mostly university-educated people in Maputo, Mozambique's largest and best-connected city. As we will describe later, there are infrastructure, market, and affordability challenges across Mozambique that impede improvements in access—the intersection between network availability and affordability.

4.1 IMPACTS TO DATE

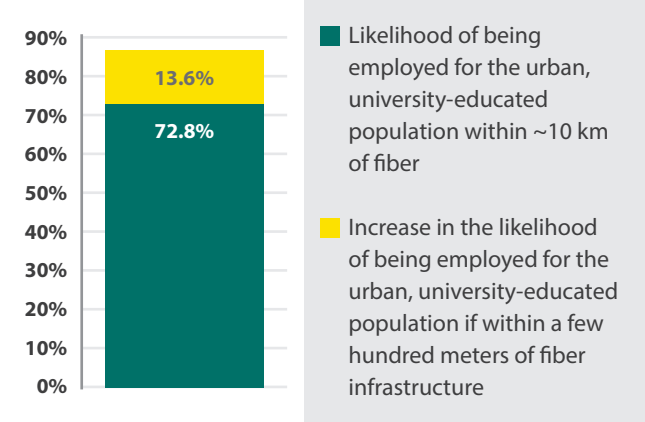
Subsea cable arrivals in Mozambique may have caused increases in employment, but only in select areas. These select areas comprise places that are connected to the terrestrial fiber network and in which access is affordable for the university-educated population living there. Results from our analysis suggest that such areas are the exception rather than the rule in Mozambique. Most significant among these places is Maputo.

By 2014, university-educated people in fiber-connected urban areas were 13.6% more likely to be employed than their peers further away from fiber (Figure 5). SEACOM and EASSy landed in 2009 and 2010, respectively. By 2014, it was apparent that people who lived within a few hundred meters of fiber infrastructure were better off than similar people in the same general area, but not as near to fiber. The difference in the likelihood of being employed is 13.6 percentage points. In other words, for people with comparable levels of educational attainment and in the same general vicinity, if they were near the fiber infrastructure their probability of being employed was 86.4% compared to their peers' 72.8%.

The proportion of urban people with university educations is a relatively small share of the population. Results for other demographic groups were less distinct. It was not possible to determine whether, for example, there were differences between people who only had primary or secondary educations.

This suggests that for the few years immediately following cable landings, the people who benefited most are those people who were positioned in life by virtue of their education and location to harness the economic opportunities stimulated by boosts in connectivity.

Figure 5. Impact of Subsea Cables on Employment Among Urban, University-Educated Working-Age People in Areas Near Terrestrial Fiber



Source: Authors' estimates.

At the national level, we were unable to detect impacts on per capita GDP or employment. Analysis of effects at such a high level, however, obscures underlying dynamics such as the varying impact by geography, demographics, and industry sector. This reinforced the conclusion that subsea cables have not had widespread impacts on Mozambique's economy overall by 2014.

Taken together, our results suggest that a small share of the population and the types of businesses in Mozambique that hire these people have benefited from subsea cables. Certainly, for those who have benefited, impacts are significant. But the positive impacts for them do not translate to appreciable impact at the national level due to the small share of the economy that these groups represent.

The benefits accruing by 2014 may seem of little consequence to much of Mozambique, but they are in fact a signal of the economic development potential improvements in connectivity can have for the country.

4.2 FORWARD-LOOKING IMPLICATIONS OF ECONOMETRIC ANALYSES

Positive economic impacts from subsea cables in Mozambique were not widespread by 2014. Relatively low levels of access to broadband—whether due to the geographic extent of infrastructure or due to affordability—is the likely explanation. If access were improved, we would expect subsea cables to have broader impacts in terms of the share of the population and economy that benefit as well as larger magnitude of those benefits.

Given the relatively narrow impact we detected, as high-speed internet infrastructure is developed it is important to consider how dynamic economic changes could affect groups within the population differently. It is possible that some groups could be left behind if they are unable to access or use the technology. It is important to consider the range of possible consequences for different groups of people and develop policies and programs to support them and mitigate any adverse impacts.

The evidence of job creation in Maputo and other urban areas where physical infrastructure and financial capital exists holds the promise of more widespread growth if awareness, access, and use of technology improves and education levels are greater. Closing gaps in access and educational opportunities may also help diminish disparities in economic opportunities across geographic and socioeconomic lines.

5. Stakeholder Perspectives on Connectivity

This section reviews the perspectives of 14 Mozambican experts in broadband connectivity. SEACOM and EASSy brought data competition, lower costs, and improved speeds to Mozambique's internet ecosystem. Despite this, experts described how poor infrastructure, market forces, and affordability problems slow the pace of broadband penetration and thereby Mozambique's ability to wring the maximum economic development value out of subsea cables and the terrestrial fiber infrastructure. Although there are 45 mobile subscriptions per 100 Mozambicans, many people have multiple SIM cards (Table 5). ARECOM estimates that only about one fifth of people have wireless service.

5.1 NETWORK EXPANSION

Provision of voice and data services in Mozambique is inhibited by infrastructure challenges (e.g., roads, electricity, network) and affordability. Subsea cables land in Maputo in the far south of the country and data is carried north by fiber that may or may not be well maintained or efficiently operated and is subject to damage by floods and construction activity. The last mile to a cell tower may be copper, which constrains network performance further.

Interviewees explained that there are also deficits in both human and financial capital to support network maintenance and expansion. The vast size of the country makes the network economics unattractive, yet there is limited infrastructure sharing among providers. Instead, providers use

Table 5. Key ICT Indicators

INDICATOR	VALUE	YEAR	SOURCE
Electrification	35% of population with access to electricity	2020	Energy Regulatory Authority
Internet users	17% of population	2020	ARECOM
Fixed broadband subscribers	0.24 subscriptions per 100 inhabitants	2018	International Telecommunication Union
Fixed Broadband Speed	1 megabits per second	2017	International Telecommunication Union
Fixed Broadband Monthly Subscription Charge	6.87 2011 USD PPP	2017	International Telecommunication Union
Mobile Cellular Subscribers	45 subscriptions per 100 inhabitants	2020	ARECOM
Mobile Download Speed	17 megabits per second	2020	Ookla Speedtest
Mobile Broadband Prepaid Subscription Charge	1.69 2011 USD PPP per 500 megabits	2017	International Telecommunication Union

their infrastructure as a competitive advantage.

The national fiber backbone provided by Tmcel (created through the merger of two bankrupt state companies, TDM and Mcel) has distance pricing for traffic, making the provision of services for its customers (as well as those ISPs to which it wholesales bandwidth) more costly than one would expect. This weakens demand because the further one travels north, the more costly service becomes, and the less likely someone may be to subscribe.

The management and engineering talent strategizing and optimizing the performance of the network for individual providers is often lacking. Although technicians and other skilled personnel are available, higher-order expertise in the areas of network design, project management, and development is in short supply. This, too, impedes network expansion. Interviewees emphasize that there is an overall need for more systems thinking and planning for complexity.

Services are reasonably good in Maputo and other cities, but nationally the service was characterized by multiple interviewees as "not great." Many people have multiple SIM cards or phones and switch cards or devices depending on their location. The closer one is to a district center or provincial capital, the better the service quality becomes.

Mozambicans have three wireless providers from which to choose: Vodacom, Tmcel, and Movitel. Movitel disrupted the market by launching services in rural areas, and building its network towards urban centers. It quickly became a major player and broke a duopoly between the other two players.

About half of the population can access 3G networks; 6% are covered by 4G.[23] Roughly 95% of mobile subscriptions are prepaid. Mobile broadband (3G or better) is part of about two-thirds of all subscriptions.[24]

Vodacom, Movitel, and Tmcel each operate their own fiber backbones. As of this writing, Movitel's network is thought to account for roughly 25,000 km of a total fiber network of 45,000 km. Most ISPs, of which there are 15 to 20, lease fiber from Tmcel at significant expense and then compete based on quality of service and support. There is very little negotiation on pricing and often providers face the same tariffs from their competitors that the competitors offer their subscribers. There are some signals that infrastructure sharing may grow, such as for towers, but overall infrastructure is viewed as key to winning more subscribers.

23 GSM Association. 2018. *Mozambique | Detail and Analysis*. London: GSM Association.
24 GSM Association. 2019. *Market Overview: Mozambique*. London: GSM Association.

5.2 UPTAKE PROPOSITION: PRICE, AFFORDABILITY, QUALITY OF SERVICE, AND CONTENT

Experts identified affordability of service and devices as the most significant impediment to broadband penetration. Other impediments include access to electricity for charging devices, illiteracy, and a lack of content in local languages. Most of the country relies on wireless services; fixed-line broadband service remains uncommon and is limited to urban centers.

These barriers are mitigated by a strong desire to connect, especially among immediate and extended family members who may be separated because of migration to cities for work. Interviewees emphasized the close-knit nature of Mozambican families and village communities. Sharing messages, photos, and videos is common. If a recipient is illiterate, the device is given to someone who can read it aloud. YouTube, Facebook, and WhatsApp are especially popular.

The cost of data is not thought to be unreasonable; Mozambicans are perplexed at how much more expensive data service is in neighboring South Africa. The issue is that access accounts for a significant portion of one's income in a country where GDP per capita is less than $500 per year. Table 6 presents comparative information on data pricing for countries in southeastern Africa.

Strategies for economizing on mobile wireless spending are common. People often turn their data services off and on, depending on whether they are near free wifi and whether they are expecting any messages. They will also take advantage of bundled offers from their service provider. Lastly, they

Table 6. Data Prices for Select Countries in Southern Africa

COUNTRY	MOBILE SUBSCRIPTION CHARGE FOR 500 MB (2011 USD PPP)
Mozambique	1.69
Malawi	1.62
Tanzania	1.47
South Africa	5.31
Zambia	6.55
Zimbabwe	16.17

Source: International Telecommunication Union.

often will have multiple SIM cards and use the provider that they believe best serves their particular location at any given time.

Interviewees emphasize that Mozambique needs to be more digital. There have been positive impacts from subsea cables on speeds, latency, and cost, but the affordability and infrastructure problems seem intractable. This limits the market and productivity potential of cloud services, e-commerce, and other solutions. Certain industry sectors, such as oil, gas, and mining, have substantial bandwidth requirements. Yet, Mozambique's connectivity is worse in the north, where some of the greatest economic development potential lies.

Strategies that drive down pricing would encourage more usage and greater penetration, which in turn would fuel market drivers for network expansion.

5.3 PUBLIC POLICY PRIORITIES

Interviewees note that there are multiple public-sector initiatives underway relating to the importance of broadband connectivity nationwide. Improving access, using the internet for education, community access points, and more robust fiber rings are all priorities.

There is a national broadband strategic plan with goals to increase access and expand the network, but experts do not see much in the way of policy mechanisms or funding that could give the plan teeth. What is more, they note that the national regulator, Autoridade Reguladora das Comunicações (ARECOM),[25] is in charge of the broadband plan and not the Ministry of Transport and Communications. Multiple experts appreciated that ARECOM recognizes the value of a broadband plan, but they note that ARECOM's mandate is really the design, implementation, and enforcement of rules, not on broader issues of policy or the design of policy directives.

The country is investing heavily in e-government solutions, including the development of a national financial planning and payments system. The Centro de Desenvolvimento de Sistemas de Informação de Finanças (CEDSIF) is the lead government entity.[26] The system unifies planning, procurement, payment, and other functions on a single locally-designed and -developed platform across all levels of government. Similar plans are underway for essential records and citizen services. The system unifies planning, procurement, payment, and other functions on a platform across all levels of government. Similar plans are underway for essential records and citizen services. The system (and the local teams that designed and developed it) is well respected, but there are concerns about the robustness of terrestrial fiber connections and therefore the system's quality of service for district and provincial offices.

ARECOM, the central bank, and other ministries are keen to see infrastructure sharing and network expansion. Multiple interviewees stated that new cable landings away from Maputo and in central or northern Mozambique could provide infrastructure redundancy while also disrupting the distance pricing model.

6. Conclusions

Mozambique has benefited economically from subsea cables, but those benefits largely accrued to university-educated people in Maputo, Beira, and other cities. Of these people, those who are within a few hundred meters of the fiber infrastructure are 13.6% more likely to be employed than those in the same general areas but further away from fiber. Although the benefits for these people are significant, these people constitute a minority of Mozambicans overall. Thus, there is not a detectable effect on national employment or GDP.

We interpret these narrow employment benefits as a signal of the broader economic development potential that subsea cables, more robust infrastructure, and connectivity improvements could have for the country. Subsea cables certainly have a role in the ecosystem, but experts were clear that among the most important actions that could be taken involve shoring up, expanding, and addressing last-mile issues for the terrestrial fiber infrastructure.

Our interviewees provided multiple recommendations. They encouraged strengthening rules and regulations around infrastructure sharing and enforcing these consistently. They also advised regulating pricing so as to break the distance pricing models for data traffic. The government should consider strategic alternatives to Maputo for cable landing sites, such as central or northern Mozambique. This may assist with building a more resilient national network, assuming that the backbone between the alternative landing site and Maputo is itself robust and secure.

25 See https://www.arecom.gov.mz/index.php.
26 See https://www.cedsif.gov.mz/.

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Acknowledgment

The authors wish to gratefully acknowledge the financial support of Facebook, Inc. The research design, method selection, results, and conclusions are the authors' alone.

The authors thank the Mozambican telecommunications experts who shared their insights and perspectives with us. Thank you also to Steve Song, who provided reviews and technical guidance that strengthened this work.

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November 2020

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