Economic Impacts of Submarine Fiber Optic Cables and Broadband Connectivity in South Africa

Working Paper 0214363.202.5

November 2020

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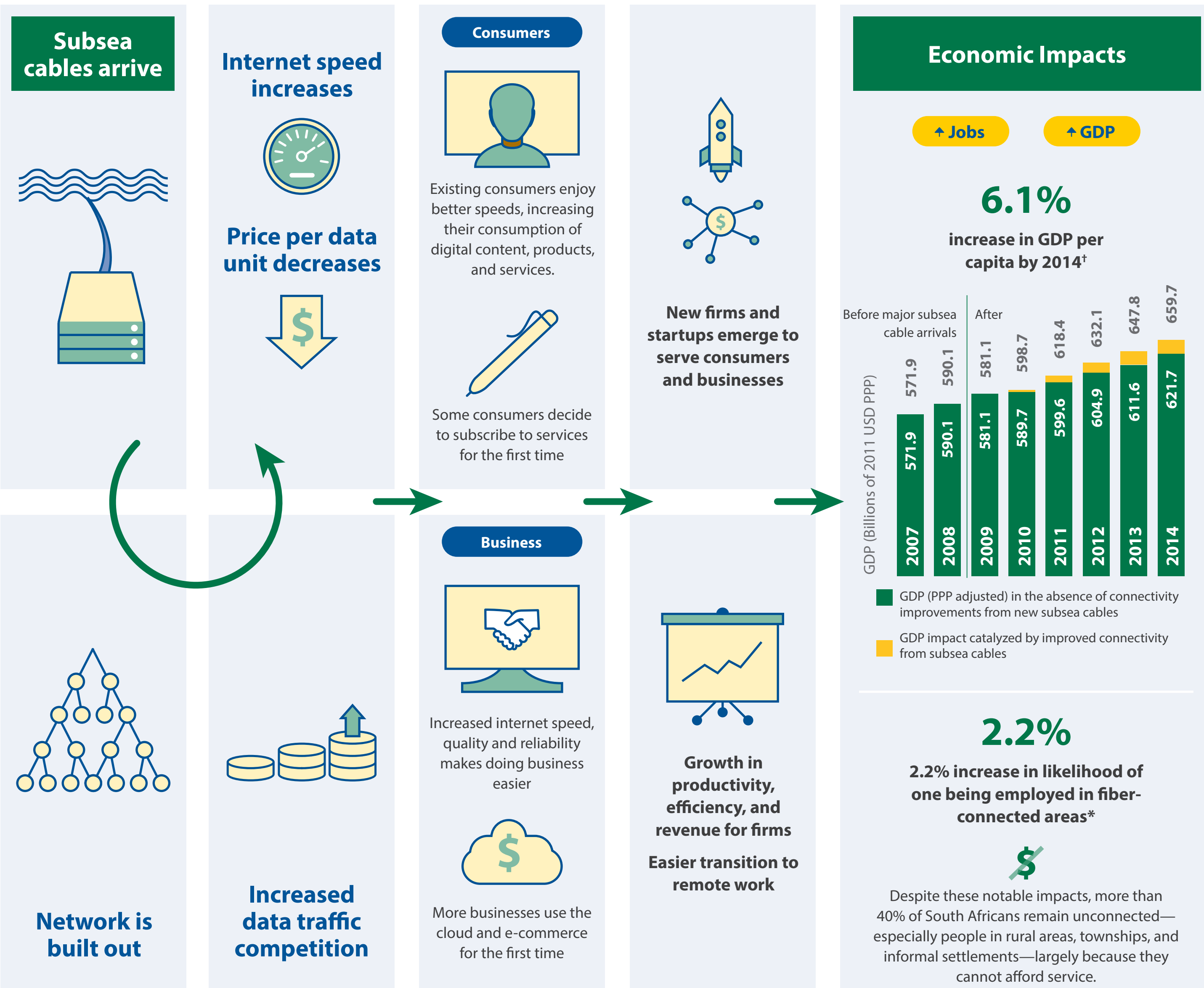
HOW DO SUBSEA CABLES GENERATE ECONOMIC IMPACT?

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 South Africa in 2009 to understand how they changed the economy. The results show that the economic impact overall was large, and there were more jobs in fiber-connected areas. However, the economic gains were not broad-based, in part because many South Africans cannot afford service.



† Subsea cables landing in 2009 catalyzed a 6.1% increase in GDP by 2014. This chart presents values at purchasing power parity (PPP), which accounts for changes in living standards over time. Doing so presents the most accurate picture of the impact that the connectivity improvement from subsea cables makes on people's lives. At PPP, in 2014 GDP was $659.7 billion instead of $621.8 billion.

For reference, in nominal terms (without any adjustments to measure living standards across time and countries), South Africa's GDP was $351 billion in 2014.

* Hjort, J, Poulsen, J. 2019. The Arrival of Fast Internet and Employment in Africa. American Economic Review, 109(3): 1032-1079.

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Recommended Citation: O'Connor, Alan C., B. Anderson, C. Lewis, A. O. Brower, and S. E. Lawrence. 2020, November. Economic Impacts of Submarine Fiber Optic Cables and Broadband Connectivity in South Africa. Working Paper 0214363.202.5. Research Triangle Park, NC, USA: RTI International.

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Recommended Citation: O'Connor, Alan C., B. Anderson, C. Lewis, A. O. Brower, and S. E. Lawrence. 2020, November. *Economic Impacts of Submarine Fiber Optic Cables and Broadband Connectivity in South Africa*. Working Paper 0214363.202.5. 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 South Africa. Subsea cables are the global backbone of the internet, connecting people, businesses, and economies around the world (Figure 1).[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 robust studies have not been conducted for many countries.[3,4] This study is one in a series our team prepared about how improvements in international data connectivity have generated economic growth for several countries in Africa.[5] We focus on recent cable landings in South Africa, such as SEACOM and EASSy.

In 2019, two academics, Jonas Hjort and Jonas Poulsen, studied the impact of subsea cables on employment in South Africa.[6] They quantified that someone is 2.2% more likely to be employed because of subsea cables if they lived within 500 meters of the fiber network.

Our team found that subsea cables' connectivity led to a 6.1% increase in GDP per capita between 2009 and 2014, even after accounting for population characteristics, economic conditions, and other important factors (Table 1). The productivity benefits are substantial. Like Hjort and Poulsen, we found employment impacts in close proximity to the fiber infrastructure, but we did not find any at the national level. It appears as if job gains are geographically concentrated.

We also looked back over the 16-year period from 2002 through 2017. We found that each 10% increase in South Africa's broadband penetration lead to a 0.27% increase in GDP per capita. Subsea cables play a role here because they increase data traffic and competition, bring down prices, further broadband uptake, and spur utilization.

South Africa has certainly benefited from cables' increases in data connectivity, but it is not clear how broad-based those gains are. Over 40% of the population does not or cannot get online. Affordability appears to be a challenge.

This study combines rigorous economic analysis with perspectives from South African telecommunications experts. We marry quantitative results with insight into the trends and developments that characterize how South Africa has leveraged subsea cable landings to economic benefit, why those benefits may not be more broadly distributed, and steps the country is taking to move forward.

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

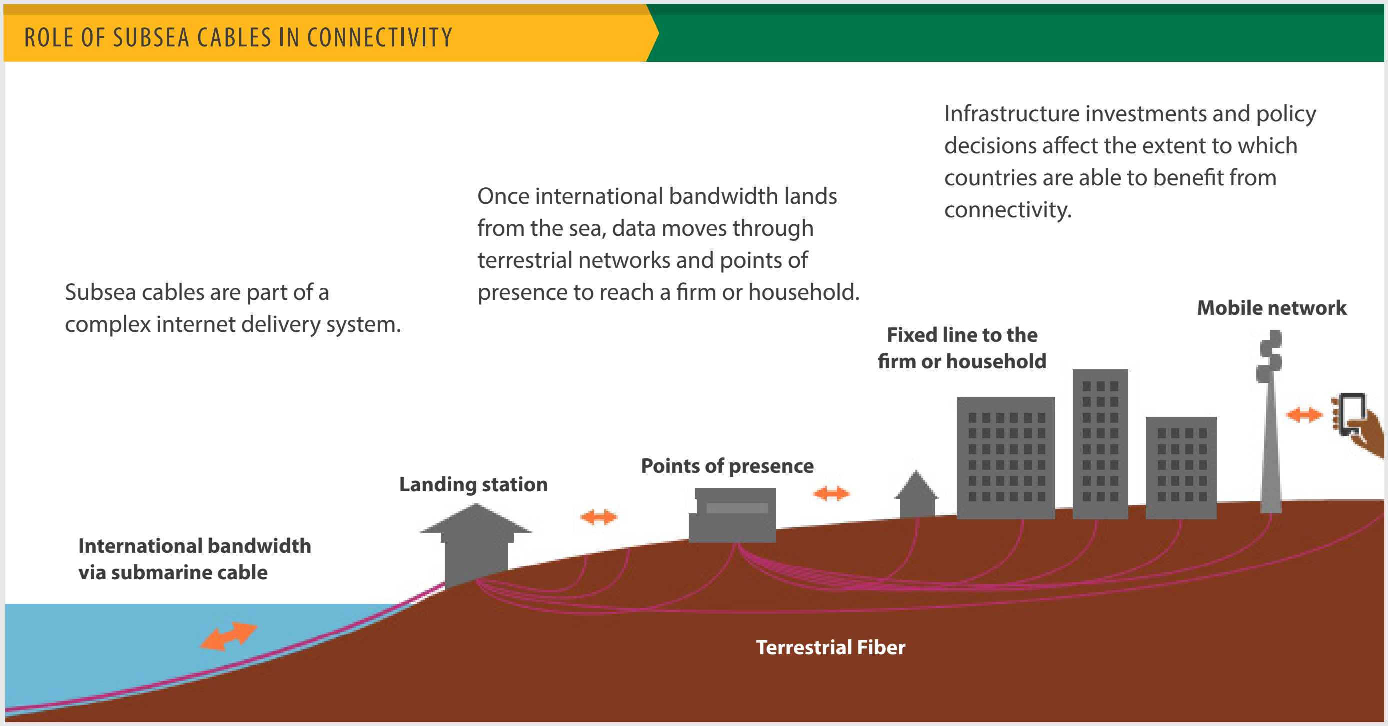
INDICATOR	TIME PERIOD	OUTCOME
Employment growth[a]	2007—2014	2.2% increase in likelihood of one being employed in fiber-connected areas
Firm growth[a]	2007—2014	23% increase in net firm entry per quarter
Economic growth[b]	2009—2014	6.1% increase in GDP per capita
Long-term economic growth[b]		
• International bandwidth consumption per user	1995—2017	0.15% increase in GDP per capita for every 10% increase in international bandwidth consumption per user
• Broadband penetration	2002—2017	0.27% increase in GDP per capita for every 10% increase in broadband penetration

[a] Hjort, J, Poulsen, J. 2019. The Arrival of Fast Internet and Employment in Africa. American Economic Review, 109(3): 1032-1079.

[b] 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 Minges, M. 2015. Exploring the Relationship between Broadband and Economic Growth. WDR 2016 Background Paper; World Bank, Washington, DC.
4 Khalil, M., Dongier, P., & Zhen-Wei Qiang, C. 2009. *Information and Communications for Development: Extending Reach and Increasing Impact*. World Bank.
5 Other countries included in this series are the Democratic Republic of Congo, Kenya, Mozambique, Nigeria, and Tanzania.
6 Hjort, J, Poulsen, J. 2019. The Arrival of Fast Internet and Employment in Africa. *American Economic Review*, 109(3): 1032-1079.

Figure 1. Role of Subsea Cables in Internet Connectivity



2. Background

South Africa is the continent's third largest economy, behind Nigeria and Egypt. While the economy has grown between 1% and 2% per year since 2017, this has been outstripped by population growth, with income per person having fallen since 2011 (RSA, 2019). Its gross domestic product (GDP)—the most common measure of the value of all goods and services produced by a country—was $351.4 billion in 2019. GDP per capita was $6,001.

South Africa's economy has long ceased to be driven by mining and agriculture. By 2018 it could be described as largely industrialized, with contributions to GDP dominated by finance, real estate and business services (22%), government services (17%), trade, catering and accommodation (15%), and manufacturing (14%) (Stats SA, 2019). By contrast, the more traditional, labor-intensive and lower-skilled sectors of agriculture, forestry and fishing (3%), mining (8%) and construction (4%) are now small segments. The country's ICT sector has struggled to grow in importance, contributing roughly 3% to GDP, according to Stats SA (Stats SA, 2017). This is just half of the OECD average of 6% (OECD, 2017).

Large numbers of South Africans are afflicted by poverty. In 2015, 19% of the population was below the international poverty line (Stats SA, 2019). In addition, South Africa's wealth is highly unequally distributed, with a mere 10% of the population holding roughly 71% of the country's net wealth in 2015. South Africa thus has an extremely high GINI Co-efficient of over 0.6 making it one of the most unequal countries in the world (Oxfam, 2019).

Unemployment, especially among youth and those without tertiary education, is a serious challenge. South Africa's official unemployment rate continues to hover stubbornly around 27%, with the expanded unemployment rate (which includes those no longer looking for work) consistently some 10% higher, currently at 39%. There is also considerable regional variation in these figures, with unemployment standing at 37% in the Eastern Cape region, compared to 22% in the neighboring Western Cape.

Table 2. Key Indicators for South Africa's Population and Economy

INDICATOR		VALUE	YEAR
Population		58.6 million people	2019
Literacy Rate		87% of population aged 15+	2017
Primary education completing rate		82% of population aged 25+	2015
Poverty rate		19 % of population below World Bank poverty line of 1.90 USD PPP/day	2014
GDP, nominal USD	• Total • Per capita	$351.4 billion 6,001	2019
GDP, nominal rand	• Total • Per capita	5.1 trillion 86,711	2019
GDP, purchasing power parity	• Total • Per capita	680.8 billion (2011 USD PPP) 12,004 (2011 USD PPP)	2017
Unemployment		27% of labor force	2018
Gini Coefficient		63	2014

Sources: Penn World Table and The World Bank.

Another way to look at South Africa'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 between countries and over time, real year-on-year changes and economic trends based on actual living standards.

Through the lens of PPP, South Africa's economy is the equivalent of $681 billion (2011 USD) with a per capita GDP of $12,004. Later, we will use the PPP method of quantifying the South African economy to generate our results, enabling impacts to be interpreted directly as improvements in living standards relative to different points in the past.

South Africa's first subsea cable—an analog affair, offering 360 channels—landed in 1967 at Melkbosstrand, north of Cape Town. It was followed in 1993 by SAT-2, which offered 565 Mbps. Both have since been decommissioned, in 1993 and 2013 respectively. Since 2009, a number of new several subsea cables have landed bringing high rates of international bandwidth to the country (Table 3). South Africa's subsea connectivity in the context of the continent as a whole can be seen in Figure 2.

Table 3. International Subsea Cable Landings for South Africa

CABLE	CURRENT CAPACITY (TBPS)	LOCAL LANDING STATION(S)	READY FOR SERVICE YEAR
SAT-3 / WASC	12.8	Melkbosstrand	2002
SAFE	12.8	Melkbosstrand & Mtunzini	2002
SEACOM	28.8	Mtzunzini	2009
Eastern Africa Submarine Cable System (EASSy)	15.36	Mtzunzini	2010
West African Cable System (WACS)	54	Yzerfontein	2012
Africa Coast to Europe (ACE)	55	Duynefontein	2020[7]
2 Africa (announced)	180	Melkbosstrand	2023
Equiano (announced)	100	Melkbosstrand	2021

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

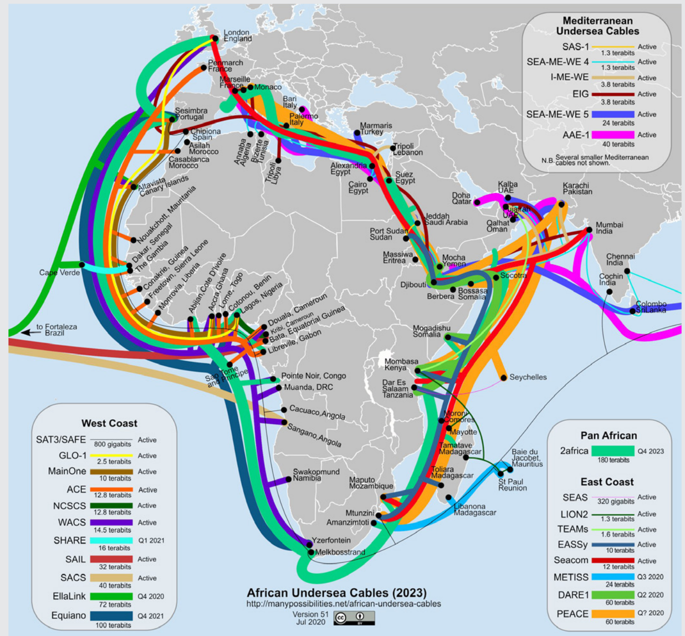
7 Construction commenced at the Duynefontein landing station in 2017, and MTN expects the cable to go live in 2020.

3. Analysis Approach

Our study paired rigorous econometric (statistical) analysis methods with interviews with 10 executives and market analysts in the South African internet ecosystem. Through this approach not only were we able to acquire insights into what the data tell us, but we were also able to identify important barriers and facilitators to South Africa's ability to derive further economic development value from subsea cables.

Note: 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 subsea 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 South Africa international connectivity is critical.

Figure 2. African Undersea Cables



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

3.1 ECONOMETRIC ANALYSES

Three complementary econometric methods quantified the impacts of subsea cable landings: difference-in-differences, synthetic control, and simultaneous equations model. Of all available methods, these offer the most robust, reliable, and accurate way to estimate causal effects in the context of subsea cables. Each derives from cutting-edge statistical techniques[8,9,10] and have been used to investigate research questions similar to those posed by our analysis.[11,12,13]

3.1.1 Difference-in-Differences (DID)

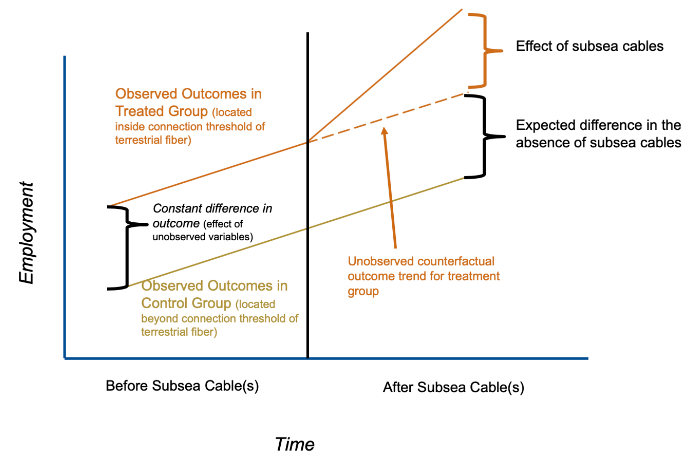
DID estimates the causal impact of subsea cables on employment and firm-level outcomes. We review DID here, having replicated analysis results first published by Hjort and Poulsen (2019).

DID consists of identifying the impacts associated with a specific intervention or treatment over some period of time. In this analysis, international data connectivity via subsea cables is 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"). Being assigned 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 on individuals used for analysis of employment came from the Statistics South Africa's Quarterly Labour Force

8 Athey, S., Imbens, G. W. 2017. The State of Applied Econometrics: Causality and Policy Evaluation. *Journal of Economic Perspectives*, 31(2): 3-32.
9 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.
10 Imbens, G. W., & Wooldridge, J. M. 2009. Recent developments in the econometrics of program evaluation. *Journal of Economic Literature*, 47(1), 5-86.
11 Hjort, J, Poulsen, J. 2019. The Arrival of Fast Internet and Employment in Africa. *American Economic Review*, 109(3): 1032-1079.
12 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.
13 Roller, L.H., Waverman, L. Telecommunications infrastructure and economic development: A simultaneous approach. *American Economic Review*, 91.4 (2001): 909-923.
14 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.
15 Quarterly Labour Force Survey, Statistics South Africa, www.statsa.gov.za.

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



Survey (QLFS),[15] which asks individuals about their employment status and type of occupation. The data for analysis of firm outcomes came from the South Africa Companies and Intellectual Property Commission's administrative dataset of firm registrations.[16] The QLFS data are geocoded and the CIPC data contain companies' postal codes, which enabled precision in the econometric approach.

Using the QLFS and CIPC data, Hjort & Poulsen (2019) were able to compare changes in employment outcomes and firm registrations (before and after subsea cables) for individuals and firms, respectively, located within a few hundred meters of the terrestrial fiber to the same changes for individuals and firms located just beyond this distance but still located within a few kilometers of the fiber.

Excluding individuals and firms 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 shocks (i.e. there would not be an event that affected a majority of one group but not the other) with the exception of subsea cables. Essentially, the only aspect differentiating individuals or firms in the treatment group from members of the control group is that those individuals and firms 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 teases 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, in addition to time invariant characteristics (which are inherently controlled for).[17]

3.1.2 Synthetic Control (SC)

SC estimates the impact of subsea cables on aggregate economic outcomes (including employment) by comparing South Africa's actual outcomes after subsea cable arrivals to a synthetic counterfactual. A synthetic counterfactual, in essence, is an alternative version of South Africa that did not experience the subsea cable landing but for which all other prevailing macroeconomic trends continued. The counterfactual is a weighted combination of similar countries which did not receive subsea cable landings during the time period of interest.

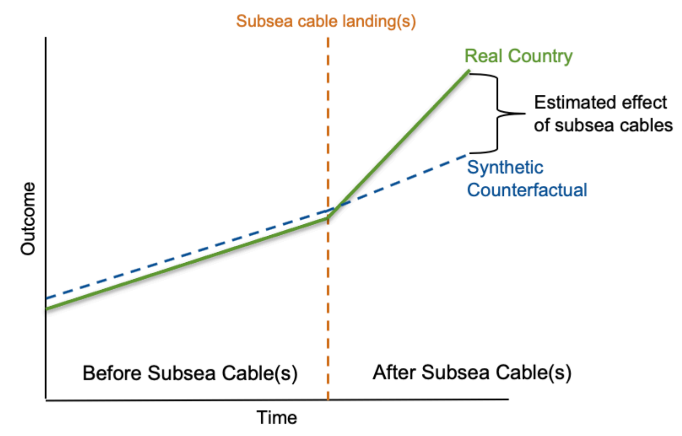
We use a weighted combination of multiple countries because the resulting counterfactual is more similar to South Africa across a variety of important and relevant dimensions, such as GDP per capita, sectoral labor composition, and urban population share, than any single comparison country alone. The construction of the counterfactual uses a completely computationally-driven matching technique that optimizes the fit of the counterfactual based on the countries' actual data. Importantly, the estimated counterfactual can be tested for its robustness and reliability, which helps quantify confidence in each set of results. See also Figure 4.

The country-level data come from the Penn World Table (PWT) and the World Bank's World Development Indicators (WDI) (Feenstra et al., 2015; World Bank Group, 2019). These sources provide relevant national statistics from officially recognized sources, which are then standardized using well-documented methodology. Importantly, the detailed methodology and data quality control measures used to standardize the data enable comparison across countries

16 South Africa Companies and Intellectual Property Commission, http://www.cipc.co.za/.

17 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

Figure 4. Synthetic Control Technique for Analysis of Subsea Cables



and over time, and thus for our application of SC to match on a variety of important macroeconomic characteristics and outcomes.

3.1.3 Simultaneous Equations Model (SEM)

SEM estimates the effect of subsea cables on GDP per capita over a long period of time by modeling national economic output and the market for broadband as a system of simultaneous equations. International bandwidth and broadband penetration are highly correlated with economic growth (GDP per capita), but this alone does not reveal anything about the causal relationships between either of the two broadband variables and GDP per capita (The Economist Intelligence Unit, n.d.).

It could be the case that international bandwidth and broadband penetration have positive effects on GDP per capita, if broadband availability and speed enable the formation of new start-ups and/or the growth of some existing businesses. Meanwhile, or alternatively, it could be true that GDP per capita has a positive effect on international bandwidth and broadband penetration because more resources are potentially available to invest in subsea cables and other broadband infrastructure. Moreover, it could be that neither of the two broadband variables cause change in GDP per capita and vice versa, and that instead the three vary together because they are driven by other distinct variables. These complexities are illustrated in Figure 5.

Jointly estimating the system of equations representing the aggregate economy and the dynamics of supply and demand within the broadband market enables us to more accurately approximate the causal impact of subsea cables on GDP per capita. The SEM approach accounts for the mutually reinforcing relationships (potential feedback loops arising from reverse causality) as well as other key explanatory factors, thus isolating the effects of a) increases in economic growth attributable to international bandwidth and broadband penetration, and b) increases in the demand and supply of international bandwidth and broadband penetration attributable to increases in economic growth.

Figure 5. Synthetic Control Technique for Analysis of Subsea Cables

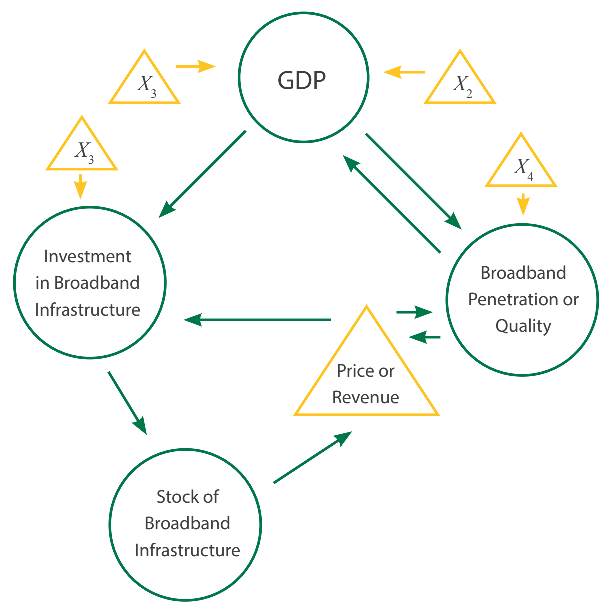


Table 4. Similarities and Differences of Econometric Analysis Strategies

IMPACT DIMENSION		DIFFERENCE IN DIFFERENCES	SYNTHETIC CONTROL	SIMULTANEOUS EQUATIONS MODEL
Treatment	Subsea cables (explicitly)	●	●	
	Broadband penetration and international bandwidth (implicitly related to subsea cables)			●
Temporality	Discrete point-in-time impacts	●	●	
	Average impact over the long-run			●
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)		●	●

3.2 THEMATIC ANALYSIS OF INTERVIEWS WITH KEY STAKEHOLDERS

We interviewed 10 South African 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.

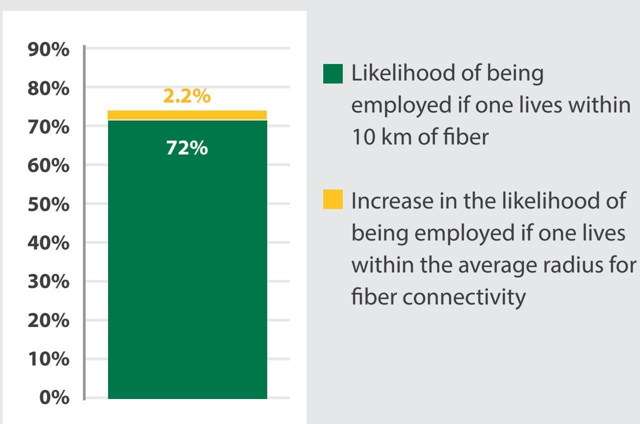
4. Economic Impacts of Subsea Cable Landings

Subsea cable arrivals in South Africa have caused modest increases in employment in areas connected to terrestrial fiber infrastructure. At the national level, we found no overall impact on employment, but we did find a 6.1% increase in GDP per capita. This suggests that cables have caused productivity increases that are concentrated in certain regions and industries.

4.1 IMPACTS TO DATE

In 2019, Hjort and Poulsen estimated that the international data connectivity enabled by subsea cables increased the likelihood of being employed by 2.2% in areas within the average fiber connectivity radius, as seen in Figure 6. This implies that for each 1 million people living in an area that is or becomes fiber-connected, 22,000 additional people tend to become employed.

Figure 6. Impact of Subsea Cables on Employment Among Working Age Individuals in Areas Near Terrestrial Fiber



Source: Hjort, J, Poulsen, J. 2019. The Arrival of Fast Internet and Employment in Africa. American Economic Review, 109(3): 1032-1079.

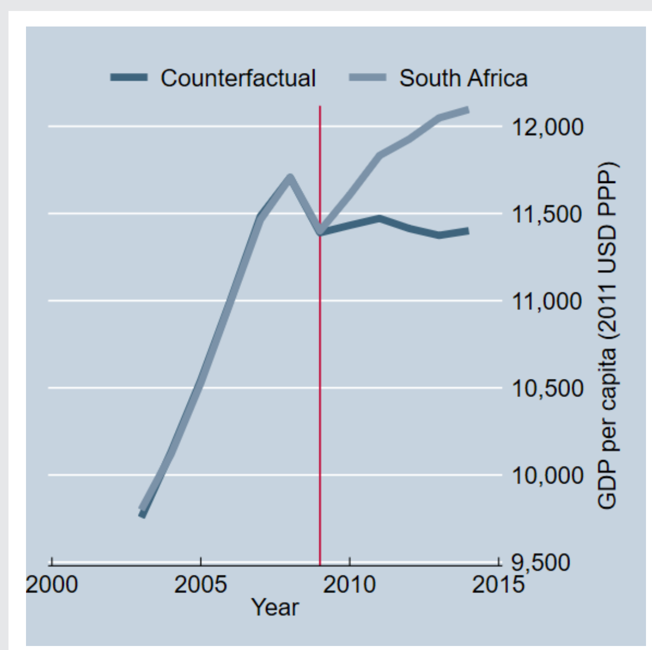
Positive effects were also found on net firm creation in areas connected to the fiber infrastructure. Hjort and Poulsen found robust evidence of an increase in net firm entry per quarter of about 23%. The impact was greatest in the financial sector with a quarterly net increase in financial firms of almost 16%, followed by the services sector with a quarterly net increase in services firms of 12%. Both sectors utilize ICT relatively intensively (World Bank, 2006).

We estimated impacts on GDP per capita, both in the short-run (to estimate recent effects which would most approximate new cable impacts) and over the long-run (to understand the role of connectivity in economic growth). This focused on the country as a whole and does not compare regions connected to fiber with those which are not.

For the country overall, we found evidence of impacts on GDP per capita in both the short- and long-run, but no impacts on employment. This suggests that employment gains in connected areas may be offset by losses in unconnected areas or that the job gains simply are not large enough.

The effects on GDP per capita reflect the impacts of subsea cable arrivals beginning in 2009 (e.g. SEACOM, EASSy, WACS) that had accumulated by 2014. Figure 7 shows the divergence of South Africa from the estimated synthetic counterfactual (what would have happened had subsea cables not arrived).

Figure 7. Estimated Effect of Subsea Cables on GDP per Capita



Source: Authors' estimates.

Table 5. **Impact of Subsea Cables' Connectivity on GDP per Capita**

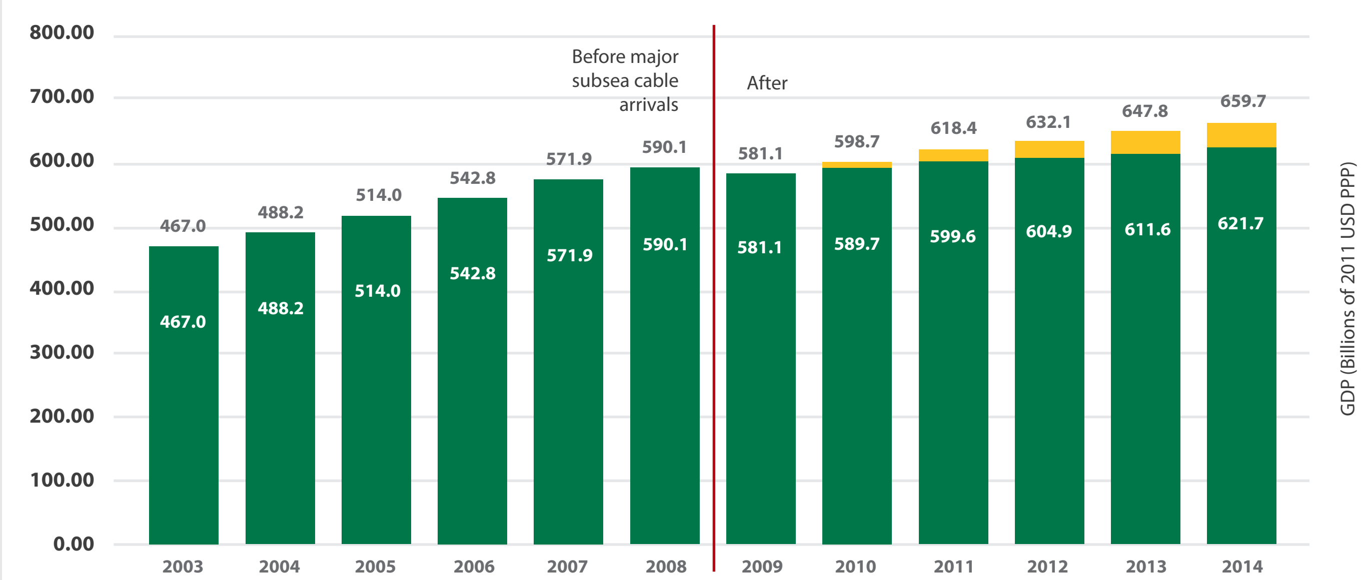
		2009	2014
2011 USD PPP	Actual	11,400	12,097
	Counterfactual	—	11,401
	Difference	—	696
2011 Rand	Actual	55,741	59,148
	Counterfactual	—	55,745
	Difference	—	3,403

Source: Authors' estimates.

In 2014, 5 years after the first of these arrivals, South Africa's actual GDP per capita was $696 greater (6.1% greater) than the counterfactual. In other words, without these subsea cables, we estimate that South Africa's GDP per capita in 2014 would have been $11,401 rather than the actual $12,097, as shown in Table 5.[18] The cumulative effect grows from 2009 to 2014, with the largest incremental impacts occurring soon after the first subsea cable arrived.

Figure 8 shows the total impact on GDP. Beginning in 2010 we see the impact of firms and individuals leveraging improved connectivity into economic growth such that we observe year-on-year changes. We estimate that if South Africa had not been able to do so its annual economic growth would have been lower. In 2014, GDP would have been $621.7 billion (at 2011 USD PPP) instead of $659.7 billion.

Figure 8. **Estimated Impact of Subsea Cables' Connectivity on South Africa's GDP at PPP**



GDP in the absence of connectivity improvements from new subsea cables

GDP impact catalyzed by improved connectivity from subsea cables

Subsea cables landing in 2009 catalyzed a 6.1% increase in GDP by 2014. This chart presents values at purchasing power parity (PPP), which accounts for changes in living standards over time. Doing so presents the most accurate picture of the impact that the connectivity improvement from subsea cables makes on people's lives. At PPP, in 2014 GDP was $659.7 billion instead of $621.8 billion.

For reference, in nominal terms (without any adjustments to measure living standards across time and countries), South Africa's GDP was $351 billion in 2014.

18 All U.S. dollar values are in 2011 USD PPP. All South African rand values are in 2011 ZAR.

Over the long run, we found large positive effects of both international bandwidth consumption per user (IBWPU) and broadband penetration on GDP per capita.

Our estimates suggest that each 10% increase in South Africa's IBWPU leads to a 0.15% increase in GDP per capita.[19] See Table 6. Illustratively, the impact of IBWPU over the past 22 years (1995 to 2017) amounts to an increase in GDP per capita of $966.

Table 6. Impact of International Bandwidth Consumption per User on GDP per Capita

For every 10% increase in IBWPU, there has been a 0.15% increase in GDP per capita	Years: 1995 – 2017
	Range of Estimate 0.11%‡ – 0.18%†

‡ p-value = 0.529   † p-value = 0.052

We identified similar effects of broadband penetration on GDP per capita. Each 10% increase in broadband penetration led to a 0.27% increase in GDP per capita. See Table 7.[20] Illustratively, the impact of broadband penetration over the last 15 years (2002 to 2017) amounts to an increase in GDP per capita of $1,707.

Table 7. Impact of Broadband Penetration on GDP per Capita

For every 10% increase in broadband penetration, there has been a 0.27% increase in GDP per capita	Years: 2002 – 2017
	Range of Estimate 0.26%‡ – 0.28%†

‡ p-value = 0.01   † p-value = 0.01

Taken together, the findings lead us to the conclusion that subsea cables have caused productivity increases in South Africa. Impacts on GDP per capita are complemented by the evidence indicating positive impacts on net firm entry in high-productivity sectors but only modest impacts on overall employment in connected areas. Cables have caused greater increases in output relative to the number of new jobs. This suggests that they are facilitating modernization and enhanced productivity in the South African economy.

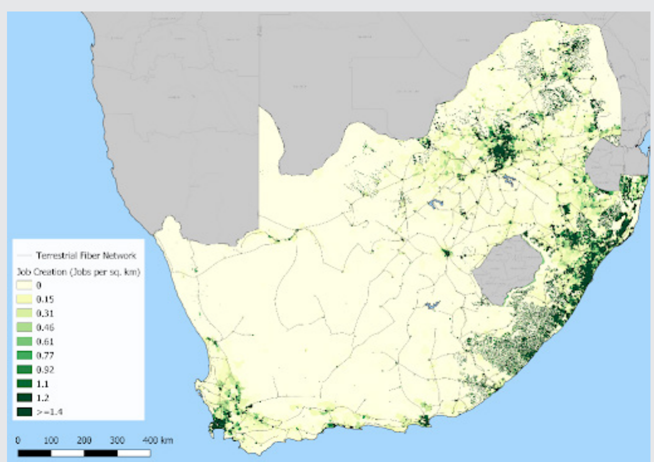
4.2 FORWARD-LOOKING IMPLICATIONS OF ECONOMETRIC ANALYSES

The modest positive effects identified on employment in fiber-connected areas offer the best estimate of the likely impacts for areas that will be connected to fiber in the future. To estimate potential job creation, we must assume that the causal effect already estimated for fiber-connected areas holds, on average, for areas that are still unconnected.

Figure 9 depicts the estimated actual and potential job creation for all of South Africa, calculated by applying the effect on employment (i.e. the increase in the likelihood of being employed) by population density (per square kilometer). For connected areas, the map shows the actual estimated job creation. For unconnected areas, the map shows potential job creation if these areas were connected (assuming the average causal effect holds). The key implication is that connecting the most densely populated areas that are currently unconnected would translate to the greatest increases in total employment.

Numerous factors influence whether the estimated effects will hold in areas that are connected in the future, including

Figure 9. Actual and Potential Job Creation as a Result of Subsea Cables and Expanded Terrestrial Fiber



19 These estimates describe the average effect of past changes in IBWPU in South Africa on GDP per capita but are not necessarily predictions of the effects of future changes, which will be determined in part by future circumstances of the country.

20 These estimates describe the average effect of past changes in broadband penetration in South Africa on GDP per capita but are not necessarily predictions of the effects of future changes, which will be determined in part by future circumstances of the country.

improvements to the technology, education levels of people living in those areas, and composition of those local economies. Obviously, the farther into the future one forecasts, the greater uncertainty there is around the magnitudes of those impacts, owing to the potential for a large degree of change from current conditions. Nonetheless, even if the effect of connecting new areas turned out to be smaller than for the effects already identified, the potential gains in terms of absolute number of jobs would be socially and economically meaningful. The same reasoning applies to firms and economic output in areas that are presently unconnected to terrestrial fiber.

5. Stakeholder Perspectives on Connectivity

The arrival of the country's first commercial undersea cable, SEACOM, in 2009, is widely credited with having disrupted the market, with having brought prices down, and with having stimulated broadband uptake. The undersea cable market initially only became open to competition with the expiry of Telkom's exclusivity over the provision of telecommunications services in 2002, but new cables were initially slow to arrive, hampered in part by unclear policy signals. [21]

First to land, SEACOM immediately targeted pricing as its competitive advantage, offering prices 15 times lower than those obtainable via Telkom's SAT-3. This impacted the market even ahead of SEACOM's arrival as Telkom sought to undercut the competitive advantage of the new entrant (Muller, 2009). Wholesale prices continued to tumble dramatically in the years that followed. Interviewees described how the availability of international bandwidth to consumers in the medium term was affected in several ways; initially, through increases in bandwidth allocation to customers, along with improvements in service quality, and, subsequently through substantial cuts in bandwidth prices (Esselaar, Gillwald, Moyo, & Naidoo, 2010).

The arrival of SEACOM initiated a flurry of subsequent landings—EASSy in 2010 and WACS in 2012—with a similar upsurge elsewhere in Africa. It initiated substantial market and value chain disruption: the cost balance between international data and local access was turned on its head, and the wider range of service options and cheaper prices, led to substantial growth in the ISP market and an upsurge in the internet user base (Goldstuck, 2012). This section reviews interviewees' perspectives on the impact of subsea cable landings.

5.1 MARKET STRUCTURE, COMPETITION, AND TRENDS

Experts emphasized the importance of understanding trends in the telecommunications sector as key to understanding the economic development potential of improvements in connectivity.

Table 8. Key ICT Indicators for South Africa

INDICATOR	VALUE	YEAR
Electrification	84% of population with access to electricity	2017
Internet users	56% of population	2017
Fixed broadband subscribers	2.4 subscriptions per 100 inhabitants	2018
Fixed Broadband Speed	2 megabits per second	2017
Fixed Broadband Monthly Subscription Charge	8.86 2011 USD PPP	2017
Mobile Cellular Subscribers	153 subscriptions per 100 inhabitants	2018
Mobile Download Speed	31 megabits per second	2020
Mobile Broadband Prepaid Subscription Charge	5.31 2011 USD PPP per 500 megabits	2017

Source: International Telecommunication Union and Ookla Speedtest.

21 See also Esselaar, S, Gillwald, A, Moyo, M & Naidoo, K (2010), South African Sector Performance Review 2009/2010, Research ICT Africa, Cape Town, South Africa.

South Africa's telecommunications market over the last 25 years has seen a difficult evolution under a process of 'managed liberalization' towards a competitive structure. A key 2008 court ruling, the Altech judgement, is widely viewed as marking a key turning point, leading to an explosion of players with licenses to build infrastructure and provide services.

Nevertheless, the mobile market remains effectively a duopoly, dominated by Vodacom and MTN, with market shares by service revenue of 49% and 32%, respectively (CompComm, 2019, p. 87). The two smaller players, Cell C (12%) and Telkom Mobile (7%) have struggled to make inroads. Together, this gives the mobile market a highly concentrated HHI score of 3,614.[22] Interviewees suspect that limited competition may be a factor in the affordability challenge that inhibits further broadband uptake. (This will be explored in greater detail later.)

The availability of mobile services is near universal and of advanced quality—described by one interviewee as a "good job" done by the licensees. Population coverage of the 3G network now stands at 99%, with 86% reached by 4G/LTE (ICASA, 2019). As we discuss further below, network availability does not necessarily mean access because of affordability challenges.

Uptake is correspondingly high, with per capita SIM card penetration now in excess of 160%,[23] and with 97% of households having access to a mobile phone (Stats SA, 2019). Mobile broadband subscriptions stand at 66 million active data SIM cards, with fixed broadband subscribers topping 7.5 million, and machine-to-machine SIMs reaching 7 million (ICASA, 2019). Device penetration, too, is at a high 82% (ICASA, 2019), although considerable numbers of users cling stubbornly to 2G handsets (Vermeulen, 2017).

The mobile market is now in the throes of a clear swing from voice to data, with data revenue growing faster than voice, and now making up 44% of service revenue for Vodacom, for example. Third-ranked operator, Cell C, has been unable to make substantive inroads into the market, leaving it in dire financial straits, prompting a last-ditch turnaround strategy that has seen it reject a takeover offer from Telkom Mobile in favor of a roaming deal with MTN. Telkom Mobile too has recently reported flat margins, despite experiencing substantial subscriber growth.

South Africa's fiber sector, by contrast, is regarded as robust and highly competitive. The early pioneers, Dark Fibre Africa (which began renting fiber cables out to licensees in 2007) and Vumatel (which launched the country's first fiber-to-the-home services in an upmarket Johannesburg suburb in 2014) have since been joined by a multitude of others.

The country's fiber backbone is substantial and growing, with a network in excess of 200,000 km. In addition to the backbone networks of Telkom, Vodacom, and MTN, major providers include: Broadband Infraco (15,000 km); Dark Fibre Africa (10,000 km); Liquid Telecom (10,000 km); Vumatel (8,000 km); and SEACOM (4,000 km).[24]

Terrestrial fiber connections are available in proximity to major cities and towns due to South Africa's extensive domestic network. This means that most of the population lives within 10 km of fiber. However, there is a lack of incentive for last-mile infrastructure development beyond the country's backbone, meaning connections to remote or impoverished areas are generally much more expensive and much less available to the public.

The provision of fiber-to-the-home connectivity has expanded dramatically in recent years, with some 35 players now connecting over 600,000 homes, in a market growing at upwards of 30% per annum (FTTX Council, 2019). The more affluent, higher-density metropolitan areas have now largely been covered, with the focus now shifting to smaller towns and less affluent, high-density areas.

South Africa's international telecommunications access is well-served by subsea cables. The country is connected to multiple high-speed undersea cables: SEACOM, EASSy, WACS and ACE (see section above). A number of additional undersea cables South Africa are reportedly in various stages of the planning process. These include: Google's Equiano, linking Portugal and South Africa; Facebook's 2Africa project that will encircle the continent; the MEIting poT Indianoceanic Submarine System (METISS), linking South Africa and Mauritius; and, possibly, a proposed cable linking South Africa to the USA.

22 The Herfindahl-Hirschman Index is a standard measure of concentration in a market. A score of above 2,500 indicates a concentrated market.

23 Partly due to multiple SIM ownership, and the growing proliferation of M2M / IoT SIM cards.

24 There have been a number of mergers and acquisitions in the fiber space in recent years: Liquid Telecom acquired NeoTel in 2017; SEACOM bought FibreCo in 2018; and Remgro's Community Investment Ventures Holdings (CIVH) secured Competition Commission permission in 2019 to add Vumatel to its existing stable of Dark Fibre Africa and SA Digital Villages.

As a result, South Africa's international bandwidth runs at an average of 850 Tbps, nearly two-thirds of which is inbound traffic (ICASA, 2019). As a result of the volume of international inbound traffic, an increasing number of providers are moving content caching and data centers onshore, a trend seen as important by several interviewees. The long-standing local Internet exchange points in Johannesburg, Cape Town and Durban have been overtaken by more than 20 carrier-neutral data centers, mainly in Johannesburg, provided by the likes of Teraco, Africa Data Centres, Internet Solutions, and Liquid Telecom. Historically, peering has been on a 'bill and keep' basis with no payments to third parties, although that arrangement looks set to change, at least at SEACOM's new data centers (Muller, 2019).

There is considerable pessimism as regards the ability of policy and regulation to break the stranglehold of the mobile duopoly in the market. Several interviewees, however, suggested that the market is ripe for disruptive intervention by a hyperscale platform or OTT provider with sufficient resources and transnational scaling to challenge the incumbents.

There are a number of trends and developments likely to feature prominently in the market over the next year or so. These include:

- Following a policy direction from the Minister, the regulator is moving ahead with plans to auction a number of lots of high-demand spectrum (ICASA, 2019), some in the currently-occupied digital dividend bands, but others in bands suitable for 4G and mid-range 5G deployments. Given the financial constraints facing the markets, it is unclear which players, beyond the duopoly of Vodacom and MTN, have the resources to enter the auction.
- At the same time, ICASA will be moving ahead with the licensing of a controversial wireless open-access network (WOAN) provider (ICASA, 2019), subject to certain privileged conditions and set-asides. It is, again, unclear at this stage which consortia will be entering the fray, which has complex linkages to the high-demand spectrum auction.
- The recently released findings of the Competition Commission's Data Service Market Inquiry (CompComm, 2019) have been bitterly opposed by Vodacom, MTN and Telkom. The ensuing squabbles and the modalities of their implementation are likely to consume considerable regulatory focus over the coming year and will put considerable pressure on the profit margins of providers across the board.
- At the same time, the sector regulator has initiated a parallel and overlapping investigation into the mobile broadband market (ICASA, 2019), with provisional suggestions that site access and roaming are areas requiring regulatory intervention.
- The recently re-amalgamated Department of Communications and Digital Technologies is also expected to introduce legislation to revise the Electronic Communications Act, which may see changes to the powers and functions of the regulator, and to the size and scope of the universal service fund.
- Finally, the country's Presidential Commission on the Fourth Industrial Revolution is expected to release its report and recommendations during 2020. The content of these is currently unknown, but it is likely to see the sector receiving greater attention from policymakers going forward.

5.2 NETWORK EXPANSION

There are a number of factors that have contributed to the expansion of South Africa's telecommunications network over the last decade. The opening up of the market and consequent expansion of infrastructure and services happened despite rather than because of policy and regulatory intervention.

A number of interviewees pointed to the pivotal impact of the 2008 Altech court case.[25] It was a ruling which overturned an attempt by the then Minister of Communications, Ivy Matsepe-Casaburri, to limit the number of infrastructure licenses being granted under the 2005 Electronic Communications Act. As a result, the regulator was obliged to issue licenses permitting all ISPs and VANS to self-provide by constructing their own networks. Network expansion through self-provisioning, constrained until then under the policy of 'managed liberalization', was thus unleashed by the courts. And the Altech ruling allowed the major operators, Vodacom and MTN, to construct their own networks, rather than having to lease bandwidth from Telkom.

25 So-called after the interdict lodged by Altech Autopage against the selective awarding of individual infrastructure licences to certain VANS operators during the conversion of existing licences to the new technology-neutral framework of the ECA. After several appeals, the Minister finally capitulated.

Other pivotal points in network expansion and user uptake, according to sector analyst, Arthur Goldstuck, include the advent of ADSL and its resale to ISPs, the advent of the smartphone, and the burgeoning FTTH market.

Some years later, with internet access and broadband assuming greater importance for universal access, and increasingly being seen as a key enabler and driver of economic growth, the Ministry moved to develop and adopt a national broadband plan, 'SA Connect' (DoC, 2013), through a process of public consultation. SA Connect, however, was over-generalized and lacked any clear priorities or implementation plan, and is now widely regarded as having failed, with rollout targets repeatedly missed and its National Broadband Council in disarray.

The proposal to establish a wireless open-access network (WOAN) seems to have originated at around the same time, driven by the same imperative to address the failure of the market to provide broadband infrastructure to under-serviced areas and communities. Envisaged as a public-private partnership, it forms a key component of SA Connect. It has extensively been criticized as an untested experiment but is currently in the preparatory stages of being licensed. The principle of open access—cost-based mandatory infrastructure sharing and facilities leasing—has been rather less controversial. Indeed, it was essentially the business model behind Dark Fibre Africa, and is now seen by the FTTX Council, as a key to infrastructure rollout.

There are a number of factors which are seen by the industry as driving up the cost of network and services rollout and as the cause of unnecessary delays.

The first of these is the shortage of spectrum, described by many as a "bottleneck". There has been no new assignment of spectrum to licensees for more than 10 years. In 2011 ICASA tabled a proposal to auction high-demand spectrum (ICASA, 2011), but this was subsequently withdrawn. Faced with the ensuing spectrum crunch, operators resorted to refarming what spectrum they had, and to constructing additional base stations, both of which served to increase the costs of service provision. Other licensees, despite the Altech judgement, without access to the necessary spectrum, have been unable to launch services. In this context, the forthcoming spectrum auction offers welcome relief, although there are concerns that high reserve prices and onerous universal service obligations may force some providers out of the running, and drive up the cost of service provision , with a knock-on effect on consumer prices and on affordability.

The cost of deployment is also a factor inhibiting network rollout, particularly in view of the long distances required to reach rural areas, where revenues per user are low, and return on capital marginal, especially in the absence of key anchor tenants, such as schools, clinics, local government offices and the like.

The lack of a national set of rapid deployment guidelines, structures and processes was repeatedly cited by interviewees as a key bottleneck holding back network deployment. This lacuna is viewed as a key policy, governance and regulatory challenge. It is a challenge all the more glaring since the development of a rapid deployment framework has been required in legislation since 2005, with a firm, legislated 12-month deadline assigned to the Minister in 2014. A recent attempt to amend the Act to include detailed rapid deployment specifications collapsed, when the Bill was withdrawn at the end of 2018.

A comprehensive rapid deployment framework would be able to address a number of issues associated with rights of way and wayleaves, with trenching making up some two-thirds of network construction costs. Currently, rights of way permissions need to be sought from multiple entities, including local governments, roads, water, electricity and railway authorities. Further, there are no country-wide, standard rules and procedures. As a result, the application process is cumbersome, arbitrary and time-consuming. Further, many local governments see wayleaves as a cash cow, setting highly variable, often exorbitant fees. In addition, lack of co-ordination and inadequate network mapping creates problems, some of which might be addressed by single trenching policies, given that the cost of trenching is around two-thirds of network capital expenditure. In addition, local communities often demand to be employed on network projects, with refusal to meet their demands leading to sabotage of the rollout.

Vandalism and theft are also ongoing problems plaguing network infrastructure, with copper cable and base station batteries, generators and solar panels a particular target—so much so that mobile operators have closed down a substantial number of base stations in vulnerable areas, and that

Telkom has discontinued the use of ADSL and other copper infrastructure.

However, despite challenges, South Africa now has an extensive national broadband backbone, fully and seamlessly integrating both fiber and wireless components.

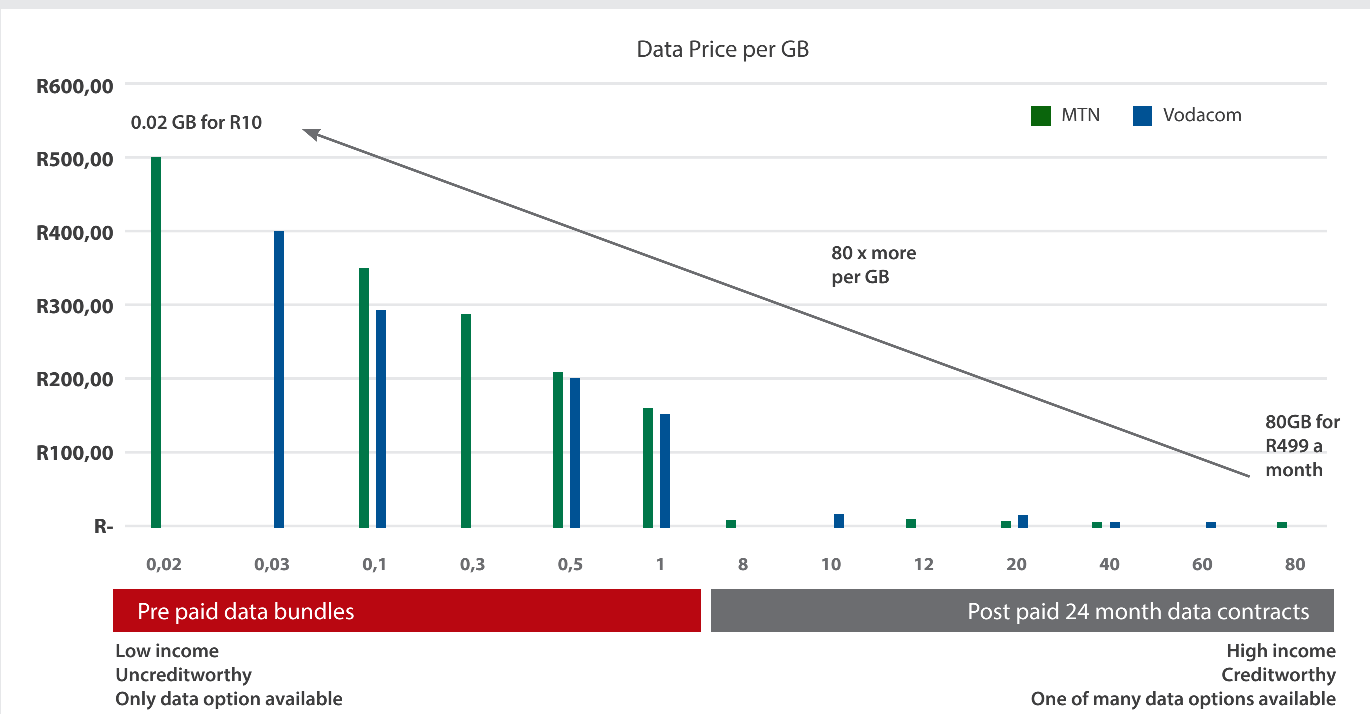
5.3 UPTAKE PROPOSITION: PRICE, AFFORDABILITY, QUALITY OF SERVICE, AND CONTENT

South Africa has excellent broadband infrastructure, as repeatedly alluded to in the interviews. The market constraints are seen to be heavily on the demand side. It is important, therefore, to look at the uptake proposition and the factors influencing demand.

Content was widely viewed by interviewees as the key demand side driver. One interviewee, for example, pointed to the exponential increase in data traffic, driven by the "appetite for content". This is particularly so for mobile prepaid data where revenue increased by 8.5% in 2018, whilst prepaid voice and messaging both decreased, by 2.9% and 22.4% (ICASA, 2019, p. 18). The FTTX Council identifies demand for streaming audio and video as a key bandwidth driver. Others identify an appetite for gaming amongst the young and the unemployed, along with the popularity of apps such as YouTube, TikTok, and Instagram. Certainly, uptake of streaming services has burgeoned in recent years, with video content provider Netflix having an estimated 300,000 subscribers, and streaming now accounting for some 9% of audio-visual content consumption (Bustech, 2019). Indeed, the trend has prompted SABC, the public broadcaster, and dominant pay-tv provider, MultiChoice, to announce the launch of subscription streaming services.

Local peering and caching arrangements, though the historical Internet exchange points (IXPs) and the more recent establishment of data centers, are both a consequence of the demand for data and content and a driver of uptake. For example, research into the evolution of the Internet in South Africa pointed to the establishment of the country's first IXPs as pivotal in stimulating Internet demand (Lewis, 2005).

Figure 10. Pricing Differentials: Pre-Paid Data Bundles vs Post-Paid Data Contracts



Source: Wireless Access Providers Association.

The demand for data notwithstanding, high prices and lack of affordability are widely seen by interviewees as a brake on access and uptake. South Africa's mobile broadband coverage reaches over 95% of the population, but more than 40% of the population do not use the Internet. Those that do overwhelmingly use mobile data. Further, data consumption for the poor largely proceeds via small prepaid purchases (as little as 20 MB at a time), whilst the affluent purchase post-paid data plans that are orders of magnitude cheaper per gigabyte (Figure 10).

Research ICT Africa notes that South Africa's data prices are less competitive when compared to other countries in Africa. And, whilst data prices have indeed fallen substantially in recent years, the Competition Commission's recent Data Services Market Inquiry estimates there is room for Vodacom and MTN to cut retail prices by a further 30%-50% (CompComm, 2019), a move that sector analyst Arthur Goldstuck suggests will be fought "tooth and nail". The Commission's report goes on to propose a number of immediate interventions designed in particular to address affordability for poorer users, including: removal of tiered pricing for smaller prepaid data bundles;[26] provisions of a daily free lifeline data allocation to all users; and zero-rating of educational and public-benefit content. Controversial and costly to the providers as some of these recommendations might be, and with implementation modalities still to be negotiated, together they have the potential substantially to stimulate uptake and demand of data and online content of various forms. The availability of budget-priced smartphones is also seen as a key to driving uptake: for example, MTN recently launched a sub-$20 basic smartphone handset.

Together, the widespread availability of affordable access and relevant content have the potential to stimulate and grow the data services market. As Goldstuck remarks: "When you have unlimited access the Internet becomes commodity rather than a scarce resource."

5.4 PUBLIC POLICY PRIORITIES

The policy and regulatory environment in South Africa is widely regarded as having been marked by lack of coherence, sluggish policymaking, and failures of implementation until 2018. Despite a much-vaunted review of ICT policy, launched in 2012, government was slow to respond to and implement its recommendations, only belatedly releasing a resultant policy white paper (DTPS, 2016).

The recent re-amalgamation of the Department under a young and enthusiastic Minister, following the recent election victory of the new ANC administration under the reformist and anti-corruption President Cyril Ramaphosa has been widely heralded. Indeed, the new President is seen to be taking the ICT sector seriously, having established a Fourth Industrial Revolution (4IR) Commission, with its first report imminent.

The new Minister is a strong proponent of the 4IR and is seen as committed to connecting the unconnected. Moves to tackle data prices and the spectrum bottleneck have been initiated, as discussed above, in addition to the licensing of the controversial WOAN. A rapid deployment task force has been established, according to the regulator.

Whilst there is a sense of optimism for the future pervading the sector, there is some concern that a next generation regulatory approach needs to be adopted. A recent policy statement by the Minister alludes to some of the above, listing as her priorities:

- Auctioning high-demand spectrum and licensing the WOAN under a "Digital Transformation Plan"
- Fast-tracking the long-stalled broadcasting migration to digital terrestrial television
- Developing a Government Data Policy for South Africa
- Finalizing a National Digital Skills Strategy
- Merging signal distributor Sentech and Broadband Infraco to form a State Digital Infrastructure Company
- Amalgamating the Film and Publications Board and the .za Domain Name Authority into ICASA
- Completing the report of the Presidential Commission on the Fourth Industrial Revolution
- Placing the State IT Agency and the Universal Service and Access Agency of South Africa under administration (DoCDT, 2019)

26 For example, a user buying 1GB of data in 20MB snippets, ends up paying over 300% more. Uncapped data access, originally introduced by M-Web, is available, but only to post-paid contract subscribers.

5.5 ECONOMIC DEVELOPMENT

South Africa currently places considerable emphasis on the 4IR, which is seen as a way of leveraging the role of ICT in restoring the country to economic growth. Appointed in early 2019, a 30-person National Commission, headed by President Ramaphosa, contains a number of high-profile appointments from the sector and from academia. It has been tasked with developing an integrated national 4IR strategy, backed by a research program and an institutional framework, in order to enhance competitiveness, and to address issues pertaining to skills development and the future of work. The Commission has divided itself into work streams focusing on:

- infrastructure and resources;
- research, technology and innovation;
- economic and social impact;
- human capital and the future of work;
- industrialization and commercialization; and
- policy and legislation.

A draft report was submitted to the President in November 2019 but has yet to be released publicly.

In an earlier effort to increase the economic and developmental impact of ICT, the Department in 2017 released a national e-Strategy (DTPS, 2017) and a national e-Government Strategy (DTPS, 2017), but the profile, implementation and impact of these has been extremely limited at best. Efforts towards e-Government remain mired in the ongoing problems of maladministration and corruption bedeviling the State IT Agency (Prior, 2019).

Government has also sought to increase the role of small- and medium-sized enterprises in economic growth and job creation, and in the ICT sector, following the release in of a Development Strategy for SMMEs in the ICT sector (DTPS, 2017), which is in part buttressed by ongoing work to strengthen broad-based black economic empowerment in the sector through the promulgation of BBBEE ICT Sector Code and the establishment of a B-BBEE ICT Sector Council. The SMME strategy has yet to be properly implemented, but, in parallel there exists a thriving ecosystem of tech hubs and ICT incubators (Giuliani & Ajadi, 2019).

Several interviewees pointed to the lack of digital skills across the society as a key challenge. Digital skills are an important foundation for citizens and consumers to interact with modern ICT, a critical requirement for job creation in conjunction with ICT technologies and those of the 4IR, but remain highly skewed along historical lines of racial and income disparities. The ICT sector too has for many years been afflicted by a persistent, ongoing skills gap (Schofield & Dwolatzky, 2019). However, a number of initiatives to address the question of digital skills are under way. The Department has established the iKamva Digital Skills Institute, and is in the process of developing a National Digital Skills Strategy. Coding as a subject is to be introduced into schools, and a program to provide learners with tablets and digital and online content is planned. There are also a number of disparate private sector initiatives to teach coding and to address the digital skills gap, including by Cisco and the ITU.

5.6 SOCIAL EMPOWERMENT AND INCLUSION

Whilst the providers interviewed tended to be more focused on commercial imperatives, there is widespread recognition of a substantial digital divide in South Africa. It is a divide that primarily affects the poor, the unemployed, and those living in rural areas. For historical reasons, its victims are disproportionately black South Africans. The scenario is often referred to by sector insiders as a new digital *apartheid*.

Certainly, the telephony divide has largely disappeared. The percentage of black South African households with either a fixed-line or a mobile telephone in their homes soared over the last 25 years to reach 94% (Stats SA, 2015, p. 25). However, white households still remain better connected, with household telephony penetration standing at 99%. The most recent figures, no longer disaggregated by race, show that over 96% of all households have functional access to telephony (Stats SA, 2019).

The technological underpinnings of the digital divide in South Africa have now shifted towards the Internet and to broadband. A recent report describes the Internet divide as a vast and multi-dimensional one "that stretches across almost every imaginable sector of society, from geography and location to income and education" (World Wide Worx, 2017). Indeed, whilst the majority of South Africans (65%) report having access to the Internet, this is largely a mobile phenomenon, with only some 10% having access to the Internet at home. Worse, the urban vs rural Internet divide is stark, between, for example, metropolitan Western Cape (where some 31% of households have access at home) and rural Limpopo and North West (where less than 1% of households do) is stark (Stats SA, 2019). Income disparities in Internet access are equally stark, with Goldstuck reporting that some 82% of rich South Africans have personally accessed the Internet in the last year, compared to 30% of the poorest (World Wide Worx, 2017). Technologically, it is effectively a two-tier market, with rich households enjoying FTTH access whilst the poorer majority have to rely on mobile handsets.

Accordingly, a number of the interviewees stressed the social imperative of connectivity, speaking about the need to address the Internet divide by providing universal affordable access for all to broadband-enabled services and content. It is an imperative that is viewed as eminently achievable. As Research ICT Africa's Gillwald points out, 90% of the population resides within 10 km of the fiber backbone.

The SA Connect national broadband plan, noted above, was a structured intervention designed to address precisely this divide. But it is an intervention that is widely recognized as having repeatedly and dismally failed to achieve its targets. An initial, controversial attempt to appoint Telkom as the lead delivery agency was withdrawn, and the project was then put out to tender through the troubled State IT Agency. The tender was subsequently withdrawn, with none of the bidders meeting the pre-qualification criteria. Reporting has largely focused on rollout targets of connecting government facilities, such as schools, clinics, post offices and police stations, but by mid-2018 only 187 out of a planned 327 sites had been connected. As a result, the Department is currently casting around for alternative best-practice rollout models (Mzekandaba, 2019). SA Connect's target of providing 90% of the country's population with Internet access at 5 Mbps by 2020 (DoC, 2013) now looks to be a hopeless pipe-dream. Nonetheless, the need for a country-wide intervention to secure the pervasive provision of fiber, along the lines of a national "Marshall Plan", as alluded to by Goldstuck, remains imperative.

The country's universal service fund, despite interventions in rolling out telecentres and other forms of connectivity, has proven singularly inept in supporting initiatives to connect under-serviced areas, and remains mired in its history of corruption and lack of sustainability.

Nevertheless, addressing the digital divide and the objectives of SA Connect remain a key priority. The FTTX Council, for example, continues to see 'connecting the unconnected' and 'FTTH for all' as central policy objectives, and suggests greater involvement on the part of the private sector is necessary. Certainly, recent forays by some of its member companies into poverty-stricken township areas in Johannesburg and Cape Town hold out the promise of a commercial model to provide affordable Internet access to the poor, albeit focused on high-density areas (Mzekandaba, 2019). Attempts to develop commercially viable Internet access models for poorer rural communities, along the lines of the Project Isizwe subsidized basic access model, await proof of concept.

6. Concluding Remarks

Our work, as well as recent work by Hjort and Poulsen (2019), point to the importance of subsea cables for South Africa. We quantified a 6.1% increase in South African GDP per capita between 2009 and 2014 because of subsea cable landings. Over the 15-year period from 2002 to 2017, for every 10% increase in broadband penetration, there was a 0.27% increase in GDP per capita. Similar results are observed over an even longer period related to international connectivity overall.

We also note that the increases in GDP have been large relative to increases in employment, suggesting that the most notable impact of subsea cables has been on productivity. We believe that job gains from the improved connectivity delivered by subsea cables to be concentrated geographically and within certain industries. Interviewees concurred with our findings, noting that although South Africa's infrastructure is robust, affordability remains a challenge, inhibiting uptake and therefore more widespread benefits.

As more of South Africa's economy shifts towards industries leveraging cutting-edge technology, highly educated and skilled segments of the labor force may be relatively better poised to take advantage of the new technology, which could contribute to widened disparities in socioeconomic outcomes across certain demographics if left unaddressed. Similarly, unconnected pockets of South Africa may be left behind as connected areas further develop.

Interviewees recommended swiftly launching spectrum auctions and developing rapid deployment frameworks as actions that would have near-term impacts on access, affordability, and availability. They also advised continuing inquiries into and addressing pricing practices, particularly for small prepaid data packages.

Given the country's history, action to address disparities in connectivity are essential to mitigate economic disparities. Policies that help improve access through pricing, such as market regulation to increase competition among service providers, would likely contribute to more equitable opportunities.

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Acknowledgment

The authors thank the South African 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.

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

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November 2020

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