Economic Impact of 2Africa

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1. Overview

This study estimates the economic impact of 2Africa, a 37,000 km submarine fiber optic cable system that will interconnect Europe, the Middle East, and 16 countries in Africa expected to become operational in 2023/4 (Figure 1). Its design capacity is 180 Tbps, which 2Africa's partners note will deliver "more than the total combined capacity of all subsea cables serving Africa today" (2Africa, 2020).[1]

The importance of connectivity to economic growth is well established[2] and underscored by our collective experience during the COVID-19 pandemic when people have switched to remote work and online communication to the extent they can. Given that broadband connectivity is essential to the efficiency and productivity that catalyze economic growth and stimulate development, it follows that an understanding of 2Africa's potential impact is important to understand. 2Africa will be a substantial step forward for Africa's connectivity.

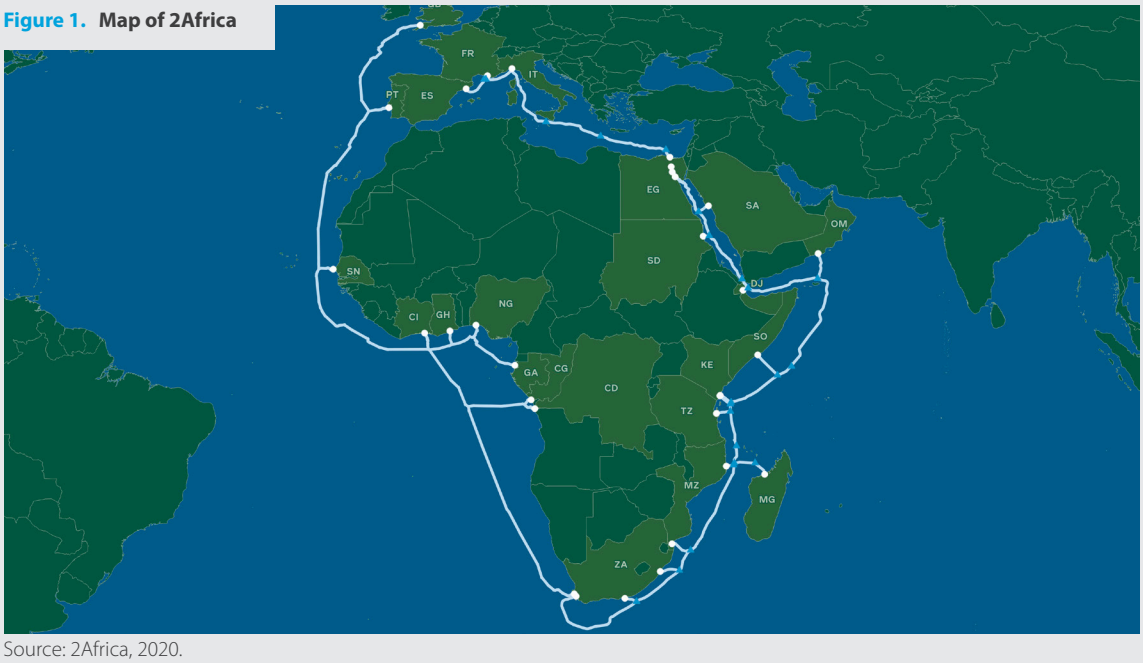
RTI International, an independent nonprofit research institute, analyzed the potential economic impact of 2Africa. We relied on the economics literature, data on broadband market conditions and trends, and insights from African telecommunications experts. In addition, we recently completed a study series that examined the comprehensive impacts of subsea cables on the Democratic Republic of Congo (DRC), Kenya, Mozambique, Nigeria, South Africa, and Tanzania (O'Connor et al., 2020a-f). The results from these studies documented the significant economic impact cable landings had on these countries between 2009 and 2017 and helped guide our analysis of 2Africa.

2Africa will generate a 26.4 to 36.9 billion USD economic impact (at PPP) for Africa within 2 to 3 years of starting operations in 2023/4.

We estimate that 2Africa will contribute a 0.42% to 0.58% impact to Africa's economy within its first 2 to 3 years of operation. This increase is equivalent to 26.4 to 36.9 billion USD at purchasing power parity (PPP[3]). Our impact estimates are conservative because there are likely to be longer-term impacts beyond this time frame. However, it is too soon to quantify what those impacts may be.

This report reviews available evidence about the impacts of subsea cables, our analysis approach, and the economic impacts we quantified.

Figure 1. Map of 2Africa



Source: 2Africa, 2020.

[1] Partners in 2Africa are China Mobile International, Facebook, MTN GlobalConnect, Orange, stc, Telecom Egypt, Vodafone, and WIOCC.
[2] See, for example, Hjort and Poulsen (2019), Minges (2015), and Khalil et al. (2009).
[3] All dollar values are presented at PPP, which accounts for differing price levels and living standards across the 54 countries in Africa. For more information, visit the International Comparison Program at https://www.worldbank.org/en/programs/icp.

2. Role of Subsea Cables in Connectivity

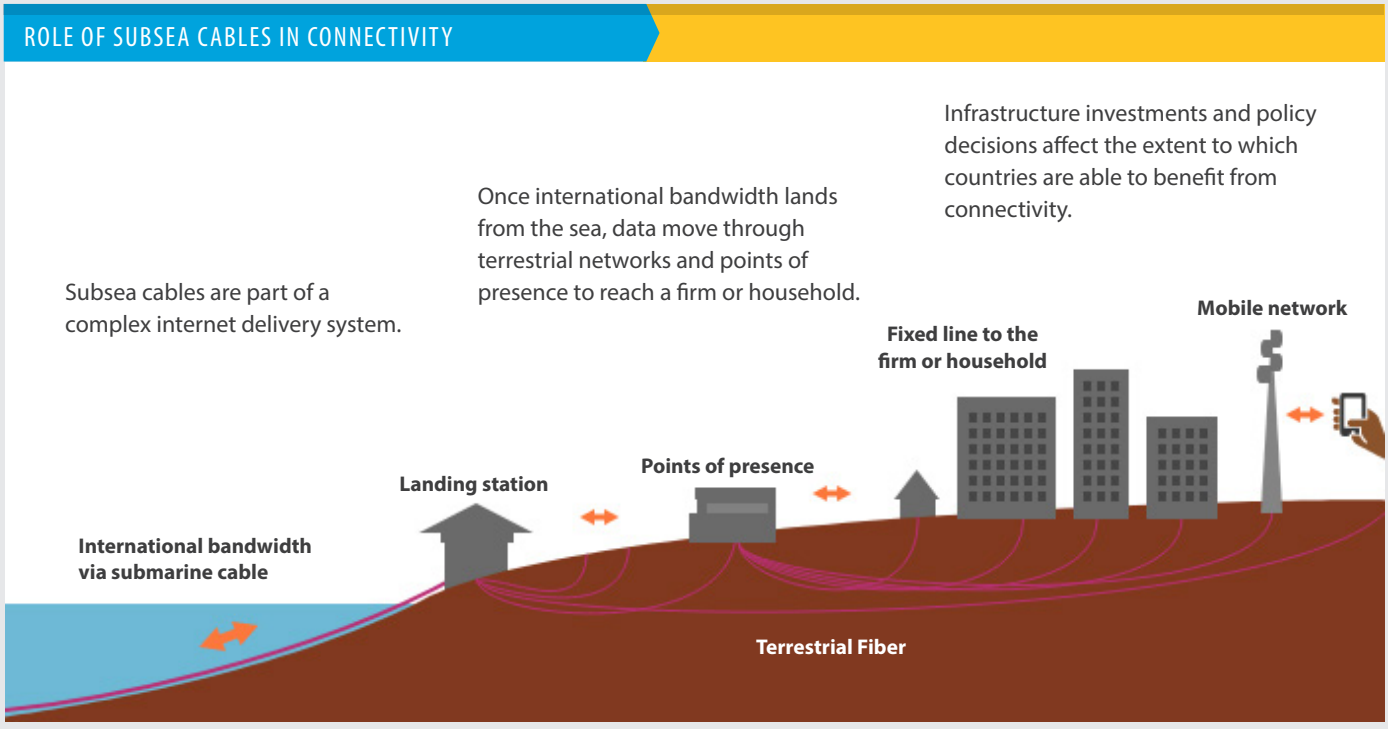
Submarine fiber optic cables, or subsea cables, are among the most important components of the Internet's infrastructure, but they are often the least well known. They are the global backbone of the Internet, connecting people, businesses, and economies around the world. About 99% of international communications traffic is carried by subsea cables (Brake, 2019). Projections estimate that the demand for broadband internet is likely to double every 2 years, further increasing the importance of subsea cable infrastructure.

As shown in Figure 2, subsea cables connect the domestic terrestrial fiber network to cloud services and data resources around the world. 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.

Figure 3 depicts subsea cables that land or are expected to land in Africa. In the 1990s, SAT-2 was the first fiber optic cable to land in sub-Saharan Africa, but for many years thereafter, Africa remained unconnected compared to other inhabited continents. There were a small number of arrivals, but subsea cable connectivity did not expand in earnest until the late 2000s. The period from 2009 to 2012 was especially active, with cables such as TEAMS, EASSy, WACS, and Seacom coming online. These cables catalyzed price decreases and network expansion and stimulated broadband penetration. Our recent report series (O'Connor et al., 2020a-f) studied the impacts these landings had on the DRC, Kenya, Mozambique, Nigeria, South Africa, and Tanzania.[4]

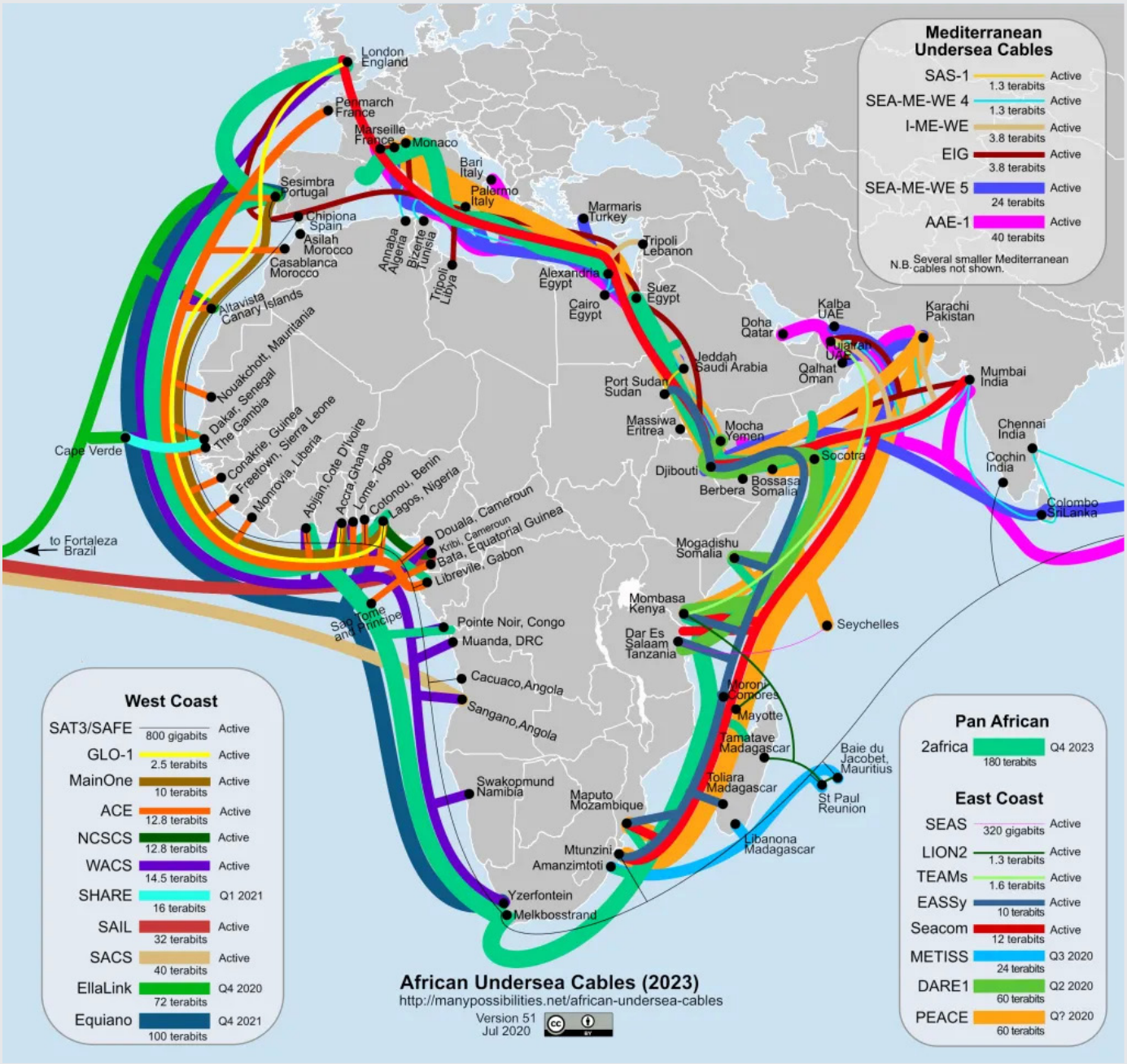
2Africa is the first subsea cable project that is designed to serve the whole of Africa, seamlessly interconnecting both the east and west coasts. The cable is expected to be 37,000 kilometers in length, nearly the circumference of the Earth. The enhanced capacity and internet connectivity brought by this project is anticipated to provide substantial improvements in speed, reliability, and cost. These improvements should help expand and enhance 4G, 5G, and fixed broadband across the continent.

Figure 2. Role of Subsea Cables in Internet Connectivity



[4] See http://www.rti.org/subsea-cables-africa.

Figure 3. **Subsea Cables in Africa**



Source: Song, S. 2020. African Undersea Cables. See https://manypossibilities.net/african-undersea-cables/

3. Trends in Economic Growth and Connectivity in Africa

This section provides background information about economic growth and internet connectivity. Our goal is not to be comprehensive—with more than 50 country markets and substantial variability in market conditions within each market that would be far beyond the scope of this work—rather, we provide enough information from which readers can appreciate the results of our analysis. We review the overall size of the continent's economy and highlights about the general state of connectivity.

Our economic analysis is for the whole of Africa because, for each country in which 2Africa lands, the market, infrastructure, and policy conditions will determine the extent to which the country derives economic development value from the cable system. Moreover, landlocked countries will also benefit from 2Africa to varying degrees, because these countries also rely on subsea cables via their coastal neighbors. Focusing on the continent as a whole affords us the opportunity to speak to 2Africa's pan-African potential.

Africa's combined GDP—the most common measure of the total value of all goods and services produced by an economy—is $2.4 trillion in current U.S. dollar terms. However, there are substantial differences in price levels, living conditions, and other salient factors across all countries.[5] A simple aggregation of the GDP of all African countries grossly underappreciates these differences.

We present our analysis results at purchasing power parity (PPP), which 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, Africa's total GDP is the equivalent of $6.3 trillion (2017 U.S. dollars) (Table 1). Over the past two decades, Africa has experienced substantial economic growth, with the economy more than doubling since 2000. Algeria, Egypt, Morocco, Nigeria, and South Africa are some of the larger economies and contributed 55% of Africa's growth in 2019 (African Development Bank Group [AFDB], 2020). Since 2016, West Africa's contribution to annual GDP growth increased from around 7% to 28%, signaling its increasingly important role in the economic growth of the continent. However, many parts of the continent still experience extreme poverty, and there are notable inequalities (AFDB, 2020).

Annual rates of growth in GDP per capita at PPP have been less than 1% in recent years (Table 2 and Figure 4). In 2019, Seychelles had the highest GDP per capita, reaching about $29,000 per person. Burundi had the lowest at $752.

Unfortunately, according to the 2020 Inclusive Internet Index, much of Africa remains unconnected (Economist Group,

Table 1. Population and Economic Indicators for Africa, 2019

TOTAL POPULATION (TRILLIONS)	TOTAL GDP (TRILLIONS OF CURRENT USD)	TOTAL GDP (TRILLIONS OF 2017 USD PPP)	GDP PER CAPITA (2017 USD PPP)	CHANGE IN GDP PER CAPITA AT PPP, 2018-2019 (%)
1.3	2.4	6.3	4,950	0.51%

Source: World Bank Development Indicators, 2020.

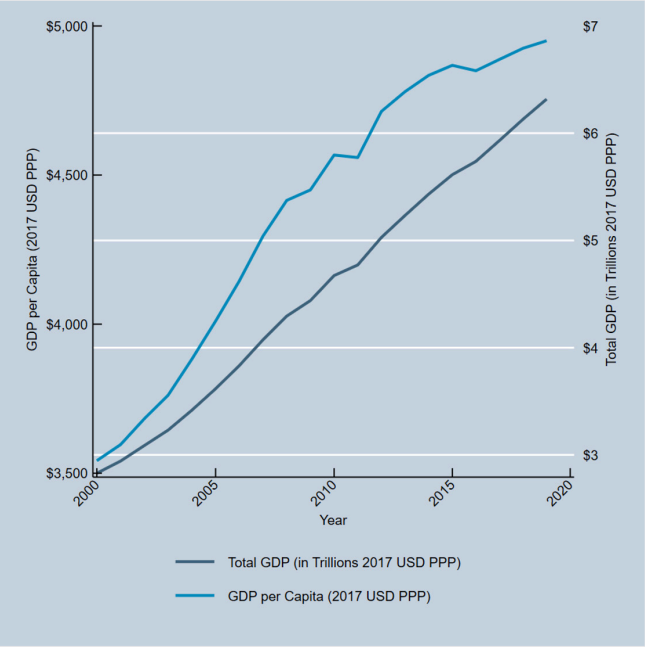
Table 2. Annual Growth Rates of African GDP per Capita (2017 USD PPP)

YEAR	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Annual growth	2.63%	–0.19%	3.40%	1.41%	1.14%	0.70%	–0.38%	0.79%	0.76%	0.51%

Source: World Bank Development Indicators, 2020.

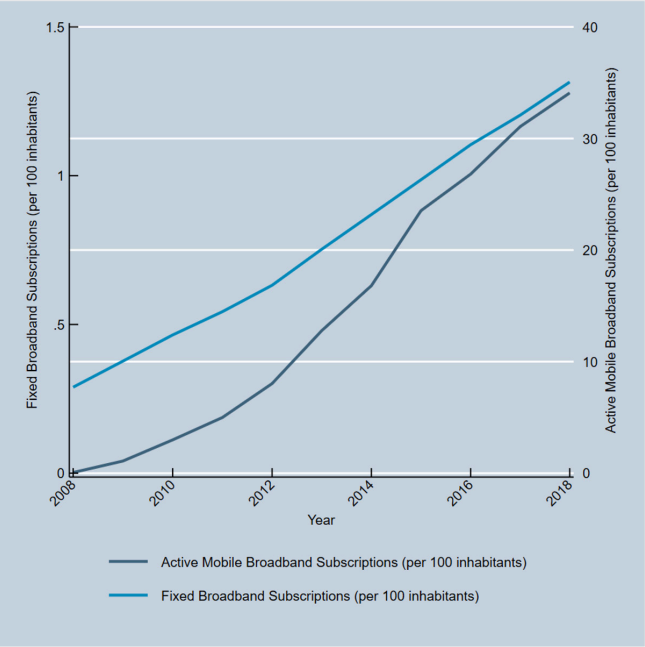
[5] Appendix A provides economic data for each country in Africa, sorted by GDP per capita at PPP.

Figure 4. Trends in Aggregate GDP and GDP per Capita across the Continent of Africa



Source: World Bank Development Indicators, 2020.

Figure 5. Active Mobile and Fixed Broadband Subscriptions per 100 Inhabitants in Africa



Sources: World Bank Development Indicators, 2020; ITU, 2020.

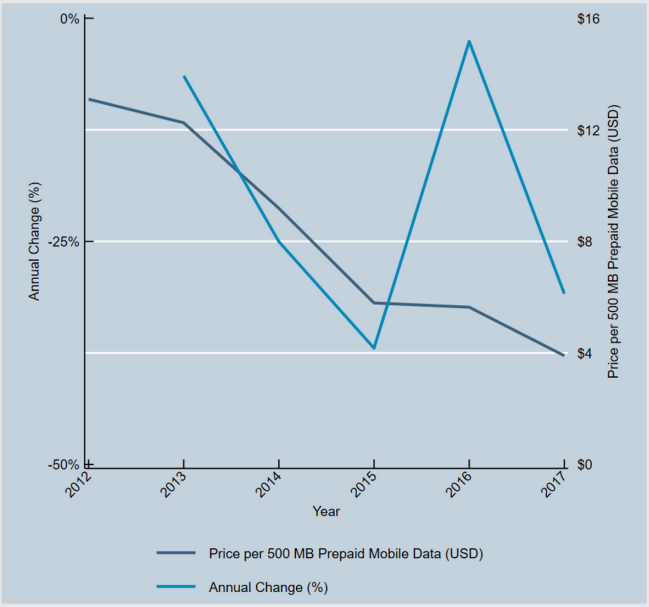
2020). There are fewer than 40 mobile subscriptions per 100 inhabitants; fixed broadband was virtually zero in 2008 and only recently reached one subscription per 100 inhabitants (Figure 5). However, broadband penetration rates vary from country to country (GSMA, 2019).

It is estimated that only 25% of Africans are online (Broadband Commission, 2019). For example, in 2017, 58.5% of the population of Seychelles was online. In contrast, only 2.7% of Burundi's population was (World Bank Development Indicators, 2020).

Internet access is unaffordable for most Africans; historically, prices for mobile data have been high relative to household income. Prices in Africa for 500 MB of prepaid mobile data range from under $1 to over $40. Appendix A shows the tremendous variation in prices across countries and illustrates that the price of data can be misaligned with average income levels.

Figure 6 presents price trends for 2012 through 2017, the most recent year for which comparative pricing data are available. Prices per 500MB tend to decline in most years as more data are consumed. These percentage changes provide an indication of the prevailing trends and offer helpful context for the price changes we expect to occur above and beyond these trends due to 2Africa, holding all else constant. These issues and estimates are discussed further in Sections 6 and 7.

Figure 6. Price Trends for Mobile Data in Africa



Source: ITU, 2020.

4. How Subsea Cables Catalyze Economic Growth

Subsea cables can drive economic growth. New cable landings catalyze a series of changes within the broadband market and economy, which can ultimately translate into economic development (Figure 7).

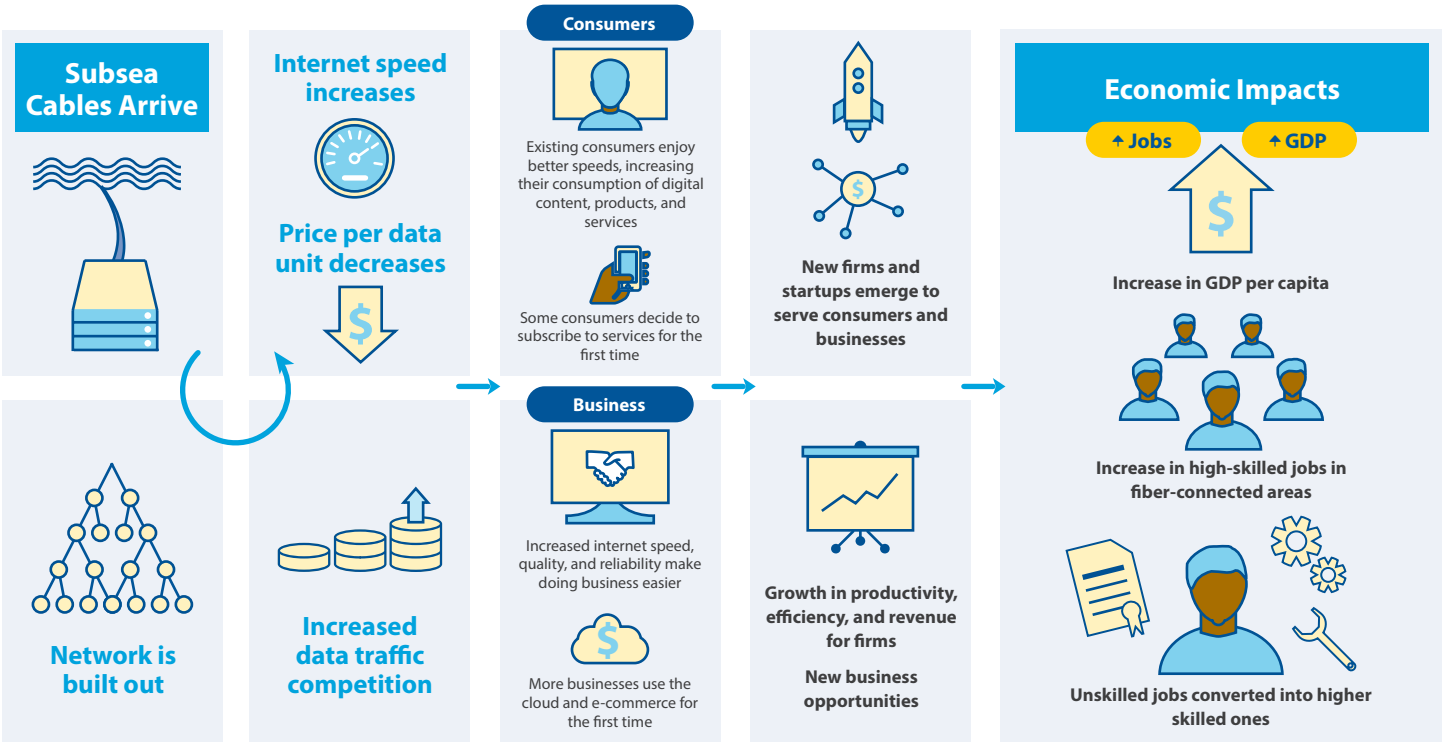
Subsea cables are fundamental and complementary to terrestrial infrastructure. The increased capacity delivered by new subsea cables relaxes constraints on international bandwidth, which creates opportunities to enhance service to existing customers and reach new ones. One way this can occur is by providers developing and expanding terrestrial networks. In certain cases, the development and expansion of terrestrial networks can lead to more competitive dynamics, which benefits both existing and new subscribers.

As value, quality, affordability, and access increase, the new and existing users will leverage the benefits in various ways. Individual consumers enjoy faster speeds, resulting in increased consumption of digital content, products, and services (O'Connor et al., 2020a-f). Additionally, increased speeds and reliability increase business efficiency and productivity. Businesses operating in many different sectors leverage these improvements in connectivity in myriad ways. Some leverage the technology for digital transactions, as in the case of the financial services industry. Others leverage connectivity improvements to access a global marketplace and opportunities to expand their supply chains and customer bases (Kende, 2017). This expansion encourages some business to try cloud platforms and e-commerce for the first time.

Increased connectivity also enables entrepreneurial activity that both creates economic value and addresses local problems. For example, the digital application CowTribe connects farmers in Ghana with veterinary services to treat sick animals (Kende, 2017). Startups leveraging connectivity enhancements span a variety of other areas such as FinTech, e-learning, and various other business-to-consumer or business-to-business services.

RTI's analysis of the impacts of subsea cables in six African countries offers a more granular analysis and empirical evidence of the economic growth and productivity-enhancing effects of these technologies. These results are discussed in more detail in the following section and help demonstrate how subsea cables can induce economic growth through productivity enhancement, employment, and revenue growth of new and existing businesses.

Figure 7. **How Subsea Cables Catalyze Economic Impacts**



5. Prior Analyses of the Economic Impacts of Subsea Cables

Recognition of the economic significance of broadband internet has attracted the attention of policymakers and development experts, stimulating a series of analyses about economic impact. A better empirical understanding of economic impacts is essential to designing policies and prioritizing infrastructure investments that will be most effective for growth.

Based on the magnitudes estimated by the most current studies, subsea cables and broadband infrastructure investments rank among the most effective development policies for economic growth in Africa (Hjort and Poulsen, 2019; Katz and Callorda, 2019). The promise of subsea cables as drivers of economic growth in Africa warrants excitement about the potential economic impact of 2Africa, specifically.

5.1 GLOBAL STUDIES

One of the earliest analyses investigating the impacts of broadband was a 2009 study by the World Bank. This study estimated that, for developing countries, each 10% increase in broadband penetration appears to boost the average GDP growth rate by 1.38 percentage points (Qiang et al., 2009).

Another study published around the same time analyzed the economic impact of broadband using a simultaneous equations (SEM) approach and data from 22 OECD (Organisation of Economic Co-Operation and Development) countries (Koutroumpis, 2009). This approach made a more explicit attempt to control for the reverse causation that may not be adequately addressed in single-equation cross-country regressions. That is, as the economy grows, there is more likely to be increased broadband penetration and data consumption. The study demonstrated that this does in fact occur, and it underscored the importance of using approaches like SEM to study the impact potential of connectivity improvements. The effects remained large: each 10% increase in broadband penetration increases GDP by about 0.25%. (This is an important point; later, we will use data from SEM approaches to quantify the potential impacts from 2Africa to ensure we do not overstate the economic impact potential.)

More recent studies have also applied the SEM approach to examine the contribution of broadband to GDP. A 2018 study published by the ITU applied an SEM approach to analyze a dataset consisting of 140 countries. Interestingly, in addition to analyzing the full 140-country dataset, the authors also split the sample into high-, middle-, and low-income countries to identify how the effects of fixed and mobile broadband penetration vary, on average, across national income levels. They found sizable effects of mobile broadband penetration on GDP among low-income countries, but smaller and less robust effects of fixed broadband (Katz and Callorda, 2018).

5.2 STUDIES SPECIFIC TO AFRICA

Evidence from econometric analyses that focused specifically on the African context are most relevant to the likely economic impact of 2Africa. Such evidence is only beginning to emerge. A 2019 study published in the American Economic Review applied a novel strategy to identify the effects of the first subsea cables to arrive to Africa on employment and found large positive effects (Hjort and Poulsen, 2019).

We released a series of studies in 2020 examining effects on employment and GDP by country for six countries in Africa. We applied similar techniques as were used in Hjort and Poulsen (2019), other econometric approaches (e.g., SEM), and extensive in-person interviews with telecommunications experts in each country. We found positive impacts in all countries, but the magnitude of the impact each country experienced differed significantly (Table 3).

Positive effects on employment were identified in all. However, impacts were more widespread among the population in some countries than in others. For example, employment impacts in DRC and South Africa appeared to be much more widespread than in Tanzania and Mozambique. In Mozambique, job benefits were mostly for urban, university-educated people.

Impacts on economic growth also varied. For example, the DRC and South Africa experienced large GDP impacts. Other countries experienced substantial impacts, but these were limited to specific ICT–intensive sectors, such as in the case of financial services in Kenya and Nigeria. The growth of specific industries points to economies in transition.

Similarly, instances in which a country experiences significant overall growth because of subsea cables but comparably less significant employment growth indicates movements toward greater productivity levels. We see interesting evidence of these economic transitions in Kenya, for example, where subsea cables caused modest overall job growth in fiber-connected areas but notable increases in skilled employment (Figure 8).

In-depth interviews and qualitative analyses accompanying our quantitative analyses identified several mediating factors that can position countries to take full advantage of subsea cables. Fostering the right set of conditions is

Table 3. Impacts of Subsea Cables on Six Countries in Africa

COUNTRY	INDICATOR	TIME PERIOD	IMPACT
Democratic Republic of the Congo	Employment	2007—2013	8.2% increase in likelihood of being employed in fiber-connected areas. For every 1 million people in these areas, an extra 82,000 tend to become employed
	Economic growth	2012—2017	19% increase in gross domestic product (GDP) per capita
Kenya	Employment	2008—2014	+ 2.5 net increase in likelihood of being employed • 8.4% increase in the likelihood of being employed in a skilled occupation • 5.9% decrease in the likelihood of being employed in a low skill occupation This means that, for every 1 million people, we see 25,000 new skilled jobs and the transformation of 59,000 jobs to higher skilled ones
	Economic growth	2009—2013	3,800% increase in financial services exports
Mozambique	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
Nigeria	Employment	2008—2013	7.8% increase in likelihood of being employed in fiber-connected areas. For every 1 million people living in connected areas, an additional 78,000 become employed, relative to unconnected areas
	Economic growth	2010—2017	1,100% increase in financial services exports per capita. The financial services sector, among the most ICT-intensive industries, is more active and productive because of subsea cables' connectivity. The impact is equivalent to a 1,100% increase in exports
South Africa	Employment[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	2009—2014	6.1% increase in GDP per capita
	Long-term economic growth		
	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
Tanzania	Employment	2009—2014	18.7% increase in the likelihood of being employed, if one lives within 200 meters of fiber infrastructure, but only in select areas

[a] Hjort and Poulsen (2019).

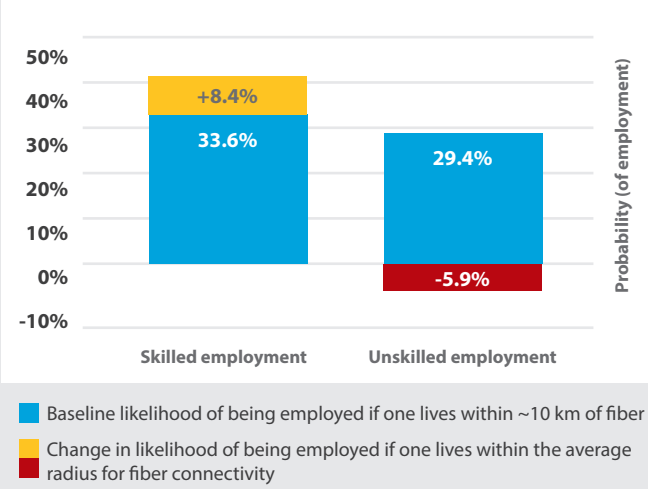
key for a country to maximize benefits from subsea cables. These conditions include policies that promote telecommunications investment and competition among providers; infrastructure development, maintenance, and protection; and investment in the skills and education levels of the population.

Most relevant to the question regarding the likely impact of 2Africa on African GDP overall is a 2019 ITU study by Raul Katz and Fernando Callorda. It relates to the global 2018 ITU study, also conducted by Katz and Callorda, but focused specifically on Africa. The authors constructed a dataset comprising 34 African countries for the years 2010 through 2017 and used an SEM approach to analyze the impacts of fixed and mobile broadband.

They found large impacts of increases in mobile broadband penetration and more modest impacts of fixed broadband. For a 10% increase in mobile and fixed broadband, there was an estimated increase in GDP per capita of 2.5% and 0.3%, respectively (Katz and Callorda, 2019).

These estimates represent the effects for Africa as a region and reflect the average of countries within Africa. Our studies showed that the effects vary from one country to the next

Figure 8. Impact of Subsea Cables on Skilled and Unskilled Employment among Working-Age Individuals in Areas near Terrestrial Fiber



(O'Connor et al., 2020a-f). The knowledge of the average effect across the continent of Africa is most helpful for the specific task of forecasting future impacts of 2Africa on Africa as a whole.

6. Analysis Approach

Our study paired rigorous econometric analyses with insights from market experts in the African internet ecosystem. The in-country experts we interviewed for this work possess extensive knowledge of market conditions and policy dynamics. Their insights were important because they helped drive our analysis approach and ensured that we took into account the likely market response to 2Africa. This section describes how we went about analyzing 2Africa's impact once it goes into service in 2024.

Note: Because terrestrial fiber and wireless networks connect users to subsea cables' landing stations, we account for them in the analysis. However, we emphasize that the impacts quantified herein are specific to the effects of 2Africa and not domestic internet connectivity. Our analysis focuses explicitly on the added value of 2Africa, taking account of trends involving nationally hosted internet exchanges, local content delivery networks, data centers, and other infrastructure that are bringing data resources onshore in many countries and which may also affect broadband markets and economic growth.

6.1 SIMULTANEOUS EQUATIONS MODEL

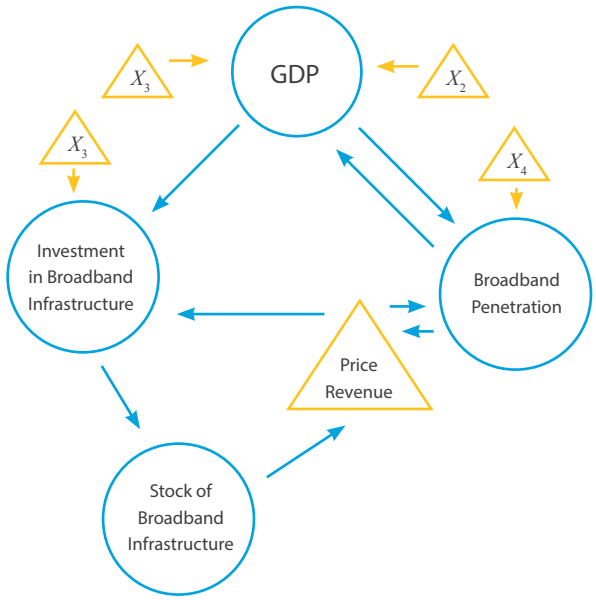
In their 2019 study, Katz and Callorda employed an econometric approach involving an SEM to estimate the relationships (1) between broadband penetration and GDP and (2) between broadband price and penetration for mobile and fixed broadband in Africa. The study used data from 34 sub-Saharan African countries and covered the period 2010 through 2017, thus covering the most representative set of countries and years for making projections relevant to 2Africa.

The SEM approach is particularly helpful for addressing questions related to the impact on GDP attributable to changes in the broadband market. It achieves this by modeling the complex dynamics between many different interacting variables in the broadband market and the economy. SEM estimates the effect of broadband 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.

Broadband penetration is highly correlated with economic growth (GDP per capita), but this alone does not reveal anything about the causal relationship between broadband penetration and GDP per capita (The Economist Intelligence Unit, n.d.). It could be that broadband penetration has positive effects on GDP per capita, if broadband availability and speed enable the formation of new startups or the growth of existing businesses. Meanwhile, or alternatively, it could be that GDP per capita has a positive effect on broadband penetration because more resources are available to invest in subsea cables and other broadband infrastructure. Moreover, it could be that broadband penetration does not cause a change in GDP per capita (or vice versa), and, instead, the two vary together because they are driven by other distinct variables. These complexities are illustrated in Figure 9.

Jointly estimating the system of equations representing the aggregate economy and the dynamics of supply and demand within the broadband market enables a more accurate approximation of the causal impact of broadband and subsea cables on GDP per capita. The SEM approach accounts for the mutually reinforcing relationships (potential feedback loops arising from reverse causality) and other key explanatory factors, thus isolating the effects of (1) increases in economic growth attributable to broadband penetration and (2) increases in the demand and supply of broadband penetration attributable to increases in economic growth. Notably, the system of equations helps isolate other important relationships including the change in broadband penetration for a given change in price, which is critical for our purposes.

Figure 9. SEM Schema



Price elasticities of demand and the effects of broadband penetration on GDP estimated by Katz and Callorda's model for Africa enable us to measure the potential impact of 2Africa. In essence, elasticities quantify the relationships between two variables, such as by how much broadband penetration may increase for a given price reduction. Given that we already have estimates for the effect of broadband penetration on GDP per capita and the price elasticity of demand for broadband, we can turn our focus to the question of 2Africa's likely impact on broadband prices. The critical elasticities estimated by Katz and Callorda (2019) that provide the foundation for making our projections are presented in Table 4. It is clear from Table 4 that there remains one critical question for us to address in order to apply the elasticities to derive projected GDP growth: What will be the likely effect of 2Africa on broadband prices, holding all else constant?

Table 2. Estimated Elasticities of Broadband Penetration to Changes in Price and Effect of Broadband Penetration on GDP per Capita

	FIXED BROADBAND	MOBILE BROADBAND
Price elasticity of demand (broadband penetration)	-0.22882	-0.31082
Effect of penetration on GDP per capita PPP	0.03031	0.24613

Source: Katz and Callorda (2019).

6.2 EXPERT INTERVIEWS

Given the elasticities provided by the SEM, assessing the change in broadband prices likely to be caused by 2Africa becomes the critical piece of information. If 2Africa does not accelerate broadband price reduction relative to prevailing trends, then it is possible that 2Africa's impacts may be profit enhancing for network operators but there may be no widespread development impacts.

As Figure 6 illustrates, prices have already been on a downward trend, at times experiencing fairly steep drops. The general trend and the relatively steep drops are due to a variety of factors including new technology and infrastructure, policies affecting the broadband market, consumer demand, and other market forces. When estimating the impact of 2Africa, all these other variables affecting price must be considered. Thus, our estimates quantify the expected difference in prices with 2Africa and a counterfactual scenario without 2Africa, taking into account prevailing trends and holding all else equal.

To answer this difficult question and validate our expected actual and counterfactual scenarios, we tapped into the knowledge and expertise of in-country experts with extensive historical and contextual knowledge of subsea cables in Africa. We polled broadband and telecommunications experts with deep knowledge about market conditions, trends, and the political dynamics in Africa, which enabled us to generate a range of price impacts. The poll was administered such that the estimates we received from the experts were independent from one another. The resulting estimates of the likely change attributable to the arrival of 2Africa ranged from a 5% to 7% decline in price, overall. (Figure 6 presents information on historical price reductions; 2Africa generating an additional reduction of 5% to 7% on top of what one would expect is not unreasonable.)

Two experts believed the reduction could be as high as 10%. Among the reasons they cited was increased competition among providers. This phenomenon has characterized previous subsea cable arrivals in Africa. These two experts explained that these dynamics, which tend to positively disrupt the market when subsea cables arrive, would likely be even more pronounced in the case of 2Africa because of its unprecedented capacity and open-consortium partnership model.

All experts acknowledged that there would be substantial variation from country to country, concurring with our sentiments that country market conditions would modulate impacts. Factors that may accentuate or attenuate the impact of 2Africa on prices include the level of development of both the broadband market and the economy more generally. Experts pointed to the ways in which countries have been responding to COVID-19. In particular, they noted how competition in local broadband markets and quality of infrastructure, as well as general levels of economic development, have aided or hindered responses to the pandemic. The experts took account of these observations related to the pandemic and how COVID-19 could influence future trends when providing their estimates of 2Africa's likely impact on prices.

6.3 ASSUMPTIONS AND LIMITATIONS

Forecasting the economic impact of 2Africa involves uncertainty around a number of issues, but recent econometric evidence provides a reasonable basis for estimating a lower-bound range for 2Africa's potential impact. Reasons for uncertainty include the potential for unanticipated changes in market conditions and the potential for changes in the size and structure of the African and global economies by 2024, due in no small part to COVID-19. Certain changes in either of these areas could modulate the economic impact of 2Africa relative to the past economic impacts of subsea cables in Africa.

There is even greater uncertainty regarding the economic impact for individual countries. Empirical evidence from our recent research indicates that the magnitude of economic impact from subsea cables varies not only by country, but also within countries (O'Connor et al., 2020a-f). The reasons for this are myriad but chiefly involve the structure of the country's broadband market and its demographic, social, and economic conditions. Major infrastructure challenges and market and regulatory paradigms that affect terrestrial networks, and therefore the ability to bring bandwidth inland, are major obstacles in multiple countries. Because of these complexities, it is most appropriate for us to focus on forecasting the economic impact for Africa as a continent, drawing on recent econometric analyses that estimated average effects and elasticities across Africa.

Our estimates of economic impact should be regarded as conservative from the perspective that we only considered 2Africa's impacts on the broadband market, in terms of prices and penetration rates, within the first year of its arrival. Thus, our projections only account for 2Africa's initial landing.

7. Economic Impact of 2Africa

Within the first 2 to 3 years of 2Africa becoming operational, we believe 2Africa will have a 0.42% to 0.58% economic impact on Africa's economy. This is equivalent to $26.4 to 36.9 billion (at PPP).

Our estimated range of impacts accounts for increases in mobile and fixed broadband penetration because of price reductions per gigabyte. Implicitly, it also accounts for improvements in speed and quality.

Our impact estimates are conservative because there are likely to be longer-term impacts beyond this time frame. However, it is too soon to quantify what those additional impacts may be. We must consider modulating factors such as the economic drag caused by COVID-19, country-level market landscapes, and infrastructure challenges overall.

We modeled expert consensus on likely price reductions (above and beyond those one would expect) and how those would affect broadband penetration. We estimate 2Africa's downward pressure on prices to catalyze a 1.6% and 1.1% increase in mobile and fixed broadband penetration, respectively, in the lower-bound scenario. In the upper-bound scenario, we estimate the pressure to catalyze an increase of 2.2% and 1.6% in mobile and fixed broadband penetration. Next, given what is known about the causal relationship between broadband penetration and GDP per capita in Africa, we can combine 2Africa's impact on broadband penetration with expected GDP impacts from increases in broadband penetration; see Table 5.

Recall from Section 3 that Africa's GDP at PPP is $6.3 trillion. Thus, an increase of 0.42% to 0.58% on GDP would equate to an impact of $26.4 billion to $36.9 billion (see Table 6). The percentages presented in Table 5 can be used to update estimates about 2Africa's potential impact. This is important because of the economic uncertainty COVID-19 has created for Africa.

Table 6. Economic Impact of 2Africa

	Lower-bound	Upper-bound
Impact on GDP per capita due to 2Africa (%)	0.42%	0.58%
Impact on African GDP, current USD	10.1 billion	14.2 billion
Impact on African GDP, USD PPP	26.4 billion	36.9 billion

Note: Estimates reflect the impact of 2Africa within the first 2 to 3 years of 2Africa becoming operational in 2023/4.
Source: Authors' calculations.

PPP takes into account the varying price levels of goods and services across countries by using detailed price data. The PPP measure thus does not fluctuate in value (purchasing power) across countries as do national currencies. In current terms (not accounting for PPP), the African economy is $2.4 trillion. From this perspective, the impact of 2Africa is projected to be $10.1 billion to $14.2 billion.

The magnitudes of these effects are extremely significant economically, both in terms of the addition to the growth rate and in terms of absolute dollar magnitude. To put these magnitudes in perspective, a growth rate of around 2% is typical for the most developed countries and, unfortunately, negative growth rates are still common among sub-Saharan African countries (World Bank Development Indicators, 2020). A boost of a half of a percent to GDP would constitute a sizable impact for any country. Thus, any investment with the potential to yield this level of growth is worthy of attention.

Table 5. Impact of 2Africa on Broadband Penetration and GDP per Capita

	FIXED BROADBAND		MOBILE BROADBAND		TOTAL COMBINED	
	Lower-bound	Upper-bound	Lower-bound	Upper-bound	Lower-bound	Upper-bound
Price change due to 2Africa [a]	-5.0%	-7.0%	-5.0%	-7.0%		
Price elasticity of demand [b]	-0.22882		-0.31082			
Change in penetration due to 2Africa (%) [c]	1.1%	1.6%	1.6%	2.2%		
Effect of penetration on GDP per capita PPP [b]	0.03031		0.24613			
Impact on GDP per capita due to 2Africa (%) [c]	0.03%	0.05%	0.38%	0.54%	0.42%	0.58%

[a] Source: Expert consensus conducted by RTI International, September, 2020. [b] Source: Katz and Callorda (2019). [c] Source: Authors' calculations.

8. Concluding Remarks

Subsea cables are fundamental to broadband penetration, internet affordability, and quality across Africa. These cables, in turn, have led to economic development through growth in employment, revenue, and productivity.

2Africa constitutes the single largest step change in international bandwidth in the continent's history. Our research suggests that this unprecedented surge will lead to decreases in broadband prices and increases in broadband penetration rates across Africa, above and beyond prevailing trends. Given what we know from the recent past, these changes in the broadband market will translate into appreciable economic growth.

Based on the most current and relevant empirical evidence, we conservatively estimate the economic impact of 2Africa to be between a 0.42% and 0.58% increase in GDP per capita for the continent within 2 to 3 years of 2Africa becoming operational. At PPP, this is equivalent to $26.4 billion to $36.9 billion.

In the headwinds of COVID-19, many economies worldwide are struggling, and it will take time for regional and global supply chains to recover. 2Africa is one factor that can mitigate headwinds by furthering connectivity and thereby making Africa's economy more nimble, resilient, and prepared to grow in the face of uncertain global conditions.

2Africa also represents an opportunity to individual countries in Africa and issues for policymakers to consider in order to maximize the potential economic development benefits. Policies that foster competition among service providers and that incentivize complementary investments in developing and maintaining terrestrial infrastructure will prime the broadband market to take fuller advantage of the immense increases in capacity brought by 2Africa. Additionally, policymakers should consider policies more broadly beyond the broadband market that could prepare greater numbers of people with the skills, education, and resources necessary to leverage the proliferation of broadband to the fullest extent. By considering such complementary policies and investments, African countries may enable both more widespread and more equitable growth.

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Appendix

Population and Economy Size Indicators for African Countries in 2019

COUNTRY	POPULATION (MILLIONS)	GDP (BILLIONS OF CURRENT USD)	GDP (BILLIONS OF 2017 USD PPP)	GDP PER CAPITA (2017 USD PPP)	CHANGE IN GDP PER CAPITA AT PPP, 2018-2019	INTERNET USERS (% OF POPULATION)	PRICE PER 500 MB PREPAID MOBILE DATA (CURRENT USD)
Seychelles	0.10	1.70	2.84	29,056	3.8%	59%[a]	7.25[a]
Mauritius	1.27	14.18	29.10	22,989	3.5%	64%	1.42[a]
Equatorial Guinea	1.36	11.03	25.16	18,558	–8.8%	26%[a]	42.27[b]
Botswana	2.30	18.34	40.93	17,766	0.8%	41%[a]	28.99[a]
Libya	6.78	52.08	102.84	15,174	1.0%	22%[a]	0.72[a]
Gabon	2.17	16.66	32.31	14,870	0.9%	50%[a]	3.44[a]
South Africa	58.56	351.43	730.91	12,482	–1.2%	56%[a]	7.42[a]
Egypt, Arab Rep.	100.39	303.18	1180.89	11,763	3.5%	57%[a]	0.84[a]
Algeria	43.05	169.99	488.64	11,350	–1.1%	49%[a]	10.81[a]
Tunisia	11.69	38.80	125.78	10,756	–0.1%	67%[a]	4.13[a]
Namibia	2.49	12.37	24.04	9,637	–3.0%	37%[a]	10.44[a]
Eswatini	1.15	4.41	9.98	8,688	1.0%	30%[a]	15.57[c]
Morocco	36.47	118.73	278.45	7,515	1.0%	74%[a]	5.16[a]
Cabo Verde	0.55	1.98	3.94	7,172	4.5%	57%[a]	3.58[a]
Angola	31.83	94.64	211.76	6,654	–4.0%	14%[a]	7.53[a]
Djibouti	0.97	3.32	5.37	5,519	5.9%	56%[a]	28.13[a]
Ghana	30.42	66.98	164.64	5,413	4.2%	38%[a]	0.69[a]
Cote d'Ivoire	25.72	58.79	134.71	5,238	4.2%	36%	3.44[a]
Mauritania	4.53	7.59	23.52	5,197	3.1%	21%[a]	30.43[a]
Nigeria	200.96	448.12	1032.05	5,135	–0.4%	7%[a]	3.27[a]
Kenya	52.57	95.50	227.64	4,330	3.0%	23%	2.42[a]
Sao Tome and Principe	0.22	0.43	0.85	3,964	0.5%	30%[a]	4.60[a]
Sudan	42.81	18.90	169.47	3,958	–4.9%	31%[a]	1.87[a]
Cameroon	25.88	38.76	94.52	3,653	1.4%	23%[a]	3.58[a]
Zambia	17.86	23.06	62.15	3,479	–1.2%	14%[d]	10.82[a]

[a]Most recent year available for this data is 2017. [b]Most recent year available for this data is 2015. [c]Most recent year available for this data is 2016. [d]Most recent year available for this data is 2018.

Population and Economy Size Indicators for African Countries in 2019 (continued)

COUNTRY	POPULATION (MILLIONS)	GDP (BILLIONS OF CURRENT USD)	GDP (BILLIONS OF 2017 USD PPP)	GDP PER CAPITA (2017 USD PPP)	CHANGE IN GDP PER CAPITA AT PPP, 2018-2019	INTERNET USERS (% OF POPULATION)	PRICE PER 500 MB PREPAID MOBILE DATA (CURRENT USD)
Senegal	16.30	23.58	55.32	3,395	2.4%	30%[a]	1.72[a]
Congo, Rep.	5.38	10.82	17.75	3,298	–3.4%	9%[a]	1.20[a]
Benin	11.80	14.39	38.79	3,287	4.0%	14%[a]	1.72[a]
Comoros	0.85	1.19	2.62	3,081	0.5%	8%[a]	4.81[a]
Zimbabwe	14.65	21.44	41.53	2,836	–9.4%	27%[a]	20.00[a]
Lesotho	2.13	2.46	5.88	2,768	0.7%	30%[a]	7.50[a]
Tanzania	58.01	63.18	149.79	2,660	2.7%	16%[a]	2.24[a]
Guinea	12.77	13.59	32.75	2,564	2.6%	22%[d]	3.22[a]
Mali	19.66	17.51	45.75	2,327	1.9%	13%[a]	8.07[a]
Rwanda	12.63	10.12	28.11	2,226	6.6%	22%[a]	2.41[a]
Ethiopia	112.08	96.11	248.78	2,220	5.5%	19%[a]	3.87[a]
Gambia, The	2.35	1.76	5.18	2,207	2.9%	20%[a]	4.18[a]
Burkina Faso	20.32	15.75	44.50	2,190	2.7%	16%[a]	4.29[a]
Uganda	44.27	34.39	96.56	2,181	2.8%	24%[a]	5.54[a]
Guinea-Bissau	1.92	1.34	3.82	1,989	2.1%	4%[a]	1.72[a]
Sierra Leone	7.81	3.94	13.43	1,718	3.3%	13%[a]	3.11[a]
Madagascar	26.97	14.08	44.40	1,646	2.1%	5%[b]	0.96[a]
Togo	8.08	5.46	12.90	1,596	2.8%	12%[a]	8.59[a]
Chad	15.95	11.31	25.19	1,580	0.2%	6%[a]	5.15[a]
Liberia	4.94	3.07	7.05	1,428	–4.6%	8%[a]	5.00[a]
Mozambique	30.37	14.93	38.88	1,280	–0.7%	21%[a]	2.52[a]
Niger	23.31	12.93	28.42	1,219	1.9%	5%[d]	0.86[a]
Congo, Dem. Rep.	86.79	47.32	95.29	1,098	1.1%	9%[a]	0.01[a]
Malawi	18.63	7.67	19.74	1,060	1.6%	14%[a]	4.79[a]
Central African Republic	4.75	2.22	4.48	945	1.3%	4%[a]	17.18[a]
Burundi	11.53	3.01	8.67	752	–1.3%	3%[a]	1.16[a]

[a]Most recent year available for this data is 2017. [b]Most recent year available for this data is 2015. [c]Most recent year available for this data is 2016. [d]Most recent year available for this data is 2018.

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