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THE EFFECT OF COVID-19 LOCKDOWN MEASURES ON INTERNET SPEED

An empirical analysis of 18 countries in Africa

Key Findings

- **Increase in internet usage** – The COVID-19 pandemic and related lockdown measures have increased the amount of internet traffic around the world. Countries in Africa reflect this global trend, reporting higher data traffic during the months in which "stay at home" orders were established. However, this increase in traffic was not temporary; countries continue to reflect a surge in traffic compared to the pre-lockdown weeks.

- **Public and private sector reaction** – As a consequence of higher internet usage, public and private stakeholders have promoted a wide range of measures to facilitate access to the internet. For instance, some regulators have enabled temporary spectrum bands to meet the increase in demand while private operators have offered more affordable data plans.

- **Internet speed is slow** – The data recorded by Ookla® Speedtest® reported on average low mobile and fixed internet speeds across the 18 African countries surveyed. Even before the onset of the pandemic, speed was below the acceptable threshold of 10mbps, considered the lower bound for a good quality broadband service. In contrast to what might be expected in OECD countries, mobile internet generally provides faster service than fixed.

- **Effect of the lockdown on internet speed was modest and temporary** – Findings from the sample of 18 African countries indicates a negative effect of the lockdown on mobile (-17%) and fixed internet speed (-5%), particularly in the first week of lockdown. Some countries also experienced a decline before the "stay at home" orders, suggesting that some activities shifted to remote connectivity before the official lockdown mandates. However, networks across the continent reacted well.

- **Public and private sector partnerships and cooperation was and remains critical for ensuring network resilience** – The findings of this study demonstrate the resiliency of digital infrastructure in Africa and also highlight and reflect the benefits of partnership between public and private stakeholders to manage traffic surges. The development community should encourage and leverage these partnerships to achieve the ambitious objective of universal access to the internet.

INTRODUCTION

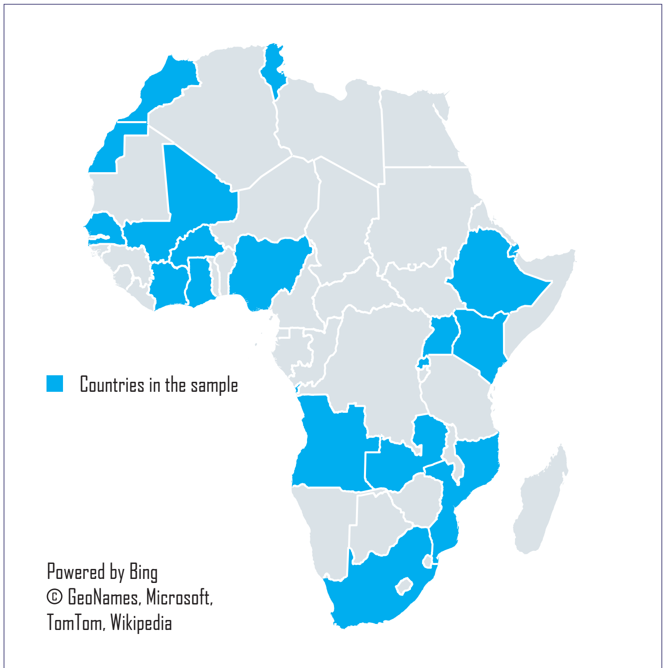
Reaching universal coverage and access to the internet is one of the biggest development challenges. 3.2 billion people in the world remain unconnected, with roughly a third of them living in Africa.[1] In the last few years however, significant milestones have been reached. For instance, the African population covered by 3G signal has increased by 186% between 2010 and 2020. 4G coverage has recorded even greater growth in Africa almost threefold in the last 5 years.[2] Despite these achievements, the development community has still not fully achieved the Sustainable Development Goal (SDG) 9, target c[3] which has the objective to "provide universal and affordable access to the internet in least developed countries by 2020."

However, the COVID-19 crisis may potentially provide the boost needed to deliver universal connectivity. COVID-19 and the related lockdown measures to prevent the virus' spread have highlighted how important it is for everyone to have access to reliable and resilient digital infrastructure. Restrictions on movement have generated higher Internet usage, reflecting an increase in remote working and learning. The "stay at home" orders have also impacted the consumption of entertainment and leisure activities, resulting in higher consumption of streaming services and online gaming.[4]

While the shift from offline to online activities has been smooth overall across advanced economies, countries with a significant digital divide are facing challenges providing the same services and opportunities to their entire populations, which may widen the inequality gap even further – both between countries and withing countries. For example, remote learning activities are key to ensuring students keep the pace of their educational growth. However, access to a reliable internet connection is a necessary input for enabling this.

In consideration of the challenges of universal connectivity and extant global digital divide, this article aims to provide insight into the effect of COVID-19-related lockdown measures on internet speed in developing countries. The objective is to raise awareness on the importance of providing internet services that meet minimum quality standards so users can perform different activities remotely in order to not only cope with lockdown measures, but also adapt to a more digitally reliant world once the global pandemic has subsided. The analysis focuses on the effect of lockdown measures on broadband speed for a subset of 18 countries in Africa, identified in Figure 1.[5] These countries were selected to provide new insight regarding countries in Africa where ICT infrastructure is less developed. Using Speedtest Intelligence data, the research relies on single-provider test data for a period of 12 weeks, straddling the peak of the pandemic and the implementation of "shelter in place" policies.[6]

FIGURE 1: 18 Countries Surveyed



This note contributes to the previous – and very limited – research on the effects of increased internet usage on both fixed and mobile broadband speed. While a myriad of topics within the domain of digital connectivity have been explored during the COVID-19 pandemic, few studies have been published on how internet speed was affected during this time period.[7] While one of the most comprehensive set of findings regarding Internet speeds during the crisis was published by Ookla in their global impact tracker covering 115 countries, this tracker excludes many of the developing countries that are the focus of this report.[8]

HOW MIGHT A SURGE IN TRAFFIC AFFECT INTERNET SPEED?

Networks are designed to manage spikes in traffic; however, these periods of heavy use are usually temporary and linked to specific events ranging from major sporting events and concerts to national emergencies and natural disasters.[9] The COVID-19 pandemic represents a much longer time frame, however. Internet traffic not only rose significantly around the globe, but it remains higher many months onward. Private and public stakeholders from different regions have reported a dramatic surge in internet consumption. For instance, British Telecom reported an increase of weekday traffic between 35-60% as people started working from home more widely.[10] Such telecom networks have limited capacity to respond in the short term, and their performance is affected by the amount of data they are required to transfer. This depends mainly on two variables: the number of users connected to the network and their activity. For instance, it is common to experience mobile connectivity issues while attending an extremely populated event such as a concert or sporting event. This happens because the mobile infrastructure can only connect a limited number of users. With fixed connectivity, having several people connected to the same home router may result in poor service quality because the capacity supplied is not enough to meet demand. The technology supporting the connection also impacts user experience. In emerging countries DSL and cable networks are more prevalent compared to fiber optic backbones, which offers lower overall speeds as shown in Table 1.

TABLE 1: Internet Speed by Technology

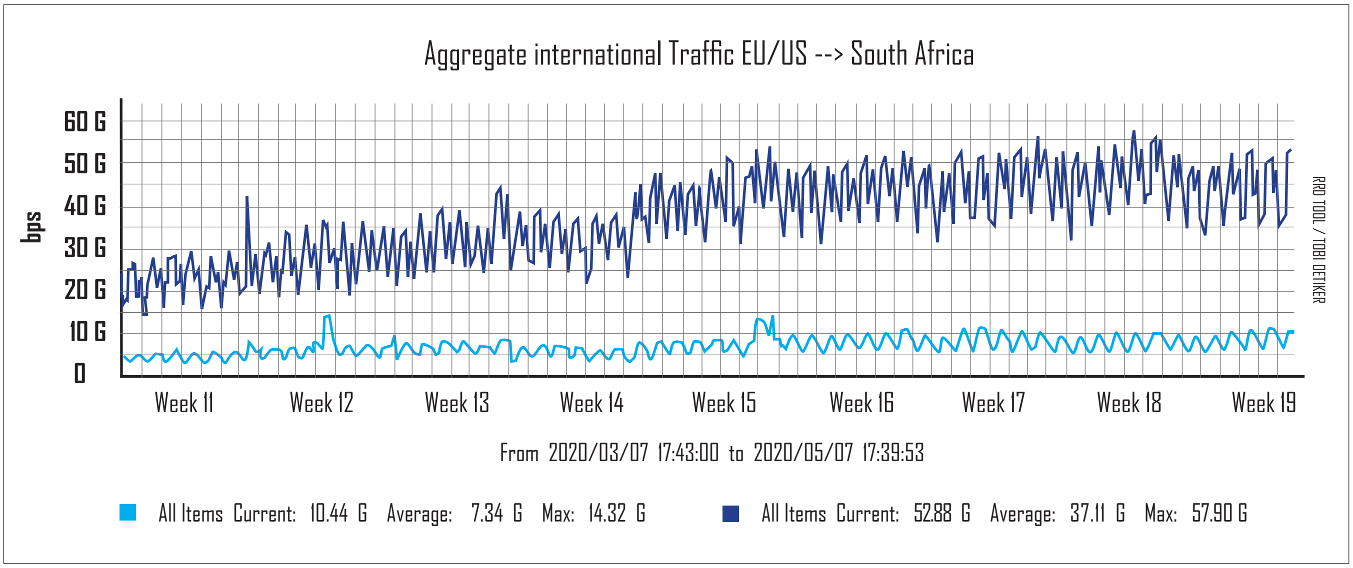
TECHNOLOGY	DOWNLOAD SPEED RANGE	UPLOAD SPEED RANGE
DSL[11]	5-35 Mbps	1-10 Mbps
Cable	10-500 Mbps	5-50 Mbps
Fiber	250-1,000 Mbps	250-1,000 Mbps

Source: BroadbandNow[12]

During the COVID-19 pandemic, increased traffic lasted for longer periods as lockdown measures were imposed by governments to prevent virus diffusion. For instance, TeleGeography estimated that international peak traffic increased by 15% globally due to COVID-19, and by 9% in Africa.[13] Looking at the statistics reported by one of the major African Internet Exchange Points (IXP)[14], the Kenya Internet Exchange Point (KIXP), data shows traffic peaks around the weeks when the "stay at home" orders were implemented, with spikes up to nearly 120 Gbps.[15] While in January 2020 traffic at KIXP was around 7.5 Gbps, it jumped to 22.6 Gbps at the beginning of March.[16] Similarly, NAPAfrica statistics[17] indicate a 30% increase in traffic immediately after the lockdown, with a modest decline after two weeks. However, traffic then surged again to stabilize around a 45% - 48% increase compared to the pre-lockdown data.[18]

Traffic was sustained not only domestically but also internationally. West Indian Ocean Cable Company (WIOCC) reported a significant increase in international IP traffic into South Africa via the West Africa Cable System submarine cable. Figure 2 shows how upstream traffic doubled from Week 11 to Week 19 of 2020 from 25 to 50 Gbps.

FIGURE 2: International Traffic from EU/US to South Africa



Source: West Indian Ocean Cable Company (WIOCC)[19]

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HOW DID THE PUBLIC AND PRIVATE SECTOR RESPOND TO THE SURGE IN TRAFFIC?

Internet infrastructure has been built to be resilient and provide reliable service even in challenging settings. Operators can manage traffic congestion by routing data in different ways to deal with a specific surge. At the same time, content providers and digital platforms can also play a role. For instance, Netflix decreased traffic by 25% by removing the highest bandwidth streams,[20] following a request from the European Union to help "ensure the smooth functioning of the Internet."[21] A similar measure was implemented by Netflix in the South African market as well.[22]

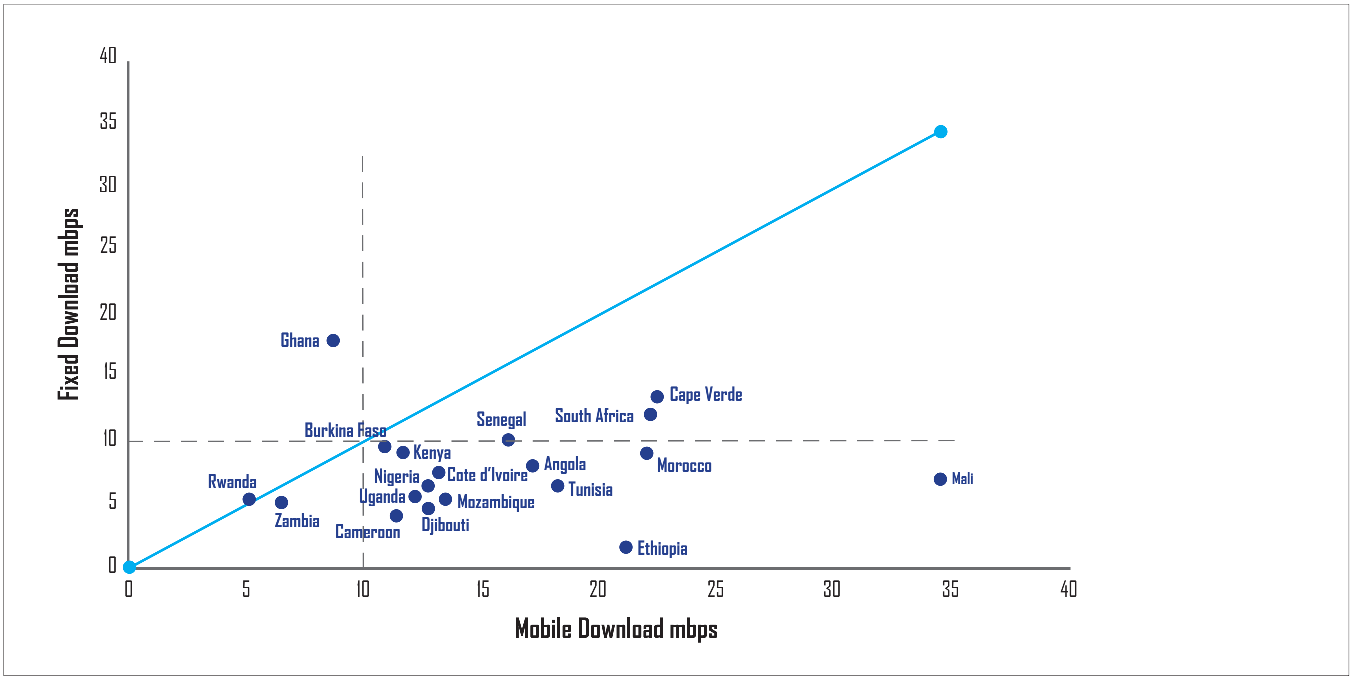
Measures were also taken by private telco operators. Several ISPs implemented data capacity upgrades in Africa, such as in Kenya where Safaricom provided double bandwidth, enabling users to use high speed internet at half the price.[23] In Mali, Orange doubled the capacity of all data plans for free.[24] The public sector played its role as well, with telco regulators being particularly active in updating their spectrum allocation policies. The National Communication Authority in Ghana granted extra spectrum to Vodafone and MTN Ghana for three months at no cost to help operators face the surge in traffic due to "stay at home" measures.[25] Similar emergency policies were adopted by the Zambia Information and Communications Technology Authority which released additional spectrum for free to improve internet efficiency.[26]

WHAT WERE THE BASELINE INTERNET SPEEDS BEFORE THE COVID-19 LOCKDOWN PERIODS?

The aim of this research was to understand if the surge in internet traffic due to lockdown measures in a sample of African countries had any consequences on mobile and fixed broadband speeds. Speedtest Intelligence data for 18 African countries was analyzed over a period of 12 weeks from the 24th February until the week of 18th May. Weekly data was collected at the operator level for both fixed and mobile connections. Ookla data relies on tests taken by users on the Speedtest website or mobile app. Tests are recorded and a rigorous statistical sampling methodology is applied to avoid biases or multiple data points for a single user.[27]

Figure 3 shows the median mobile and fixed download speed recorded for the week of 24th February 2020.[28] It should not be surprising that mobile download speed is higher than fixed speed for almost all the countries in the sample, due to the older technologies supporting the fixed network in many African markets. For instance, high-capacity fixed broadband (fiber) represents 67% of the total fixed connections in high-income countries while only 29% in low- and middle-income countries and 3% in low-income countries.[29] As of 2019, only 28% of total fixed subscribers in the sample of countries have a fiber connection. The majority of African countries in the sample reported fixed internet download speed below the 10mbps which is considered the low boundary for a good quality broadband.[30] At the same time, for the vast majority of countries, mobile internet speed is above the 10mbps threshold, reflecting the more recent vintage of this infrastructure.

FIGURE 3: Fixed and Mobile Speeds in the Sample of African countries



The speed required at the household level to perform different activities depends on many variables, including the number of connected devices, the number of individuals using the same connection and the type of activities performed over the Internet. All these elements affect the minimum internet speed needed by the user. Even the same product can be consumed to a different degree of intensity. For instance, e-learning can be provided through streaming video-calls as well as voice calls. These activities have a distinct impact on the network as noted in Table 2.[31]

TABLE 2: Internet speed by activity

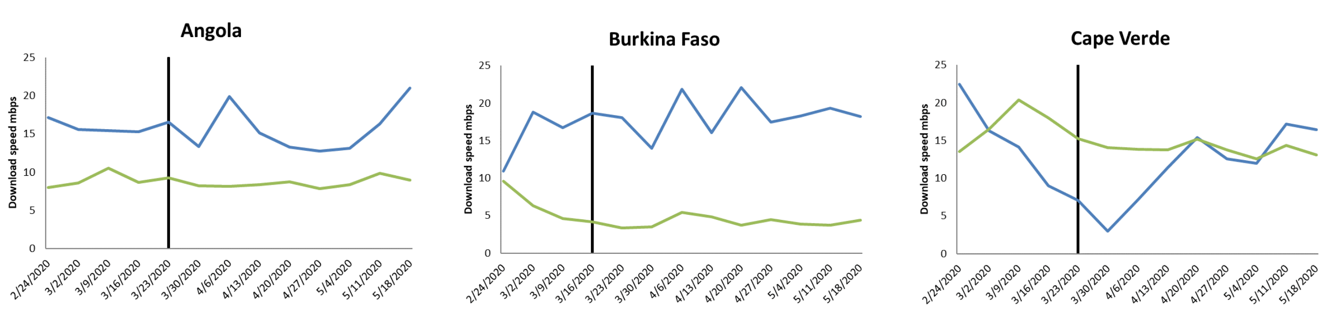
0 – 5 MBPS	5 – 40 MBPS	40 – 100 MBPS	100+ MBPS
Check email	Streaming video on one device	Streaming HD video on a few devices	Streaming video in UHD on multiple screens
Streaming music on one device	Video calling	Multiplayer online gaming	Downloading very large files quickly
Internet search	Online gaming (1 player)	Downloading large files	Online gaming for multiple players

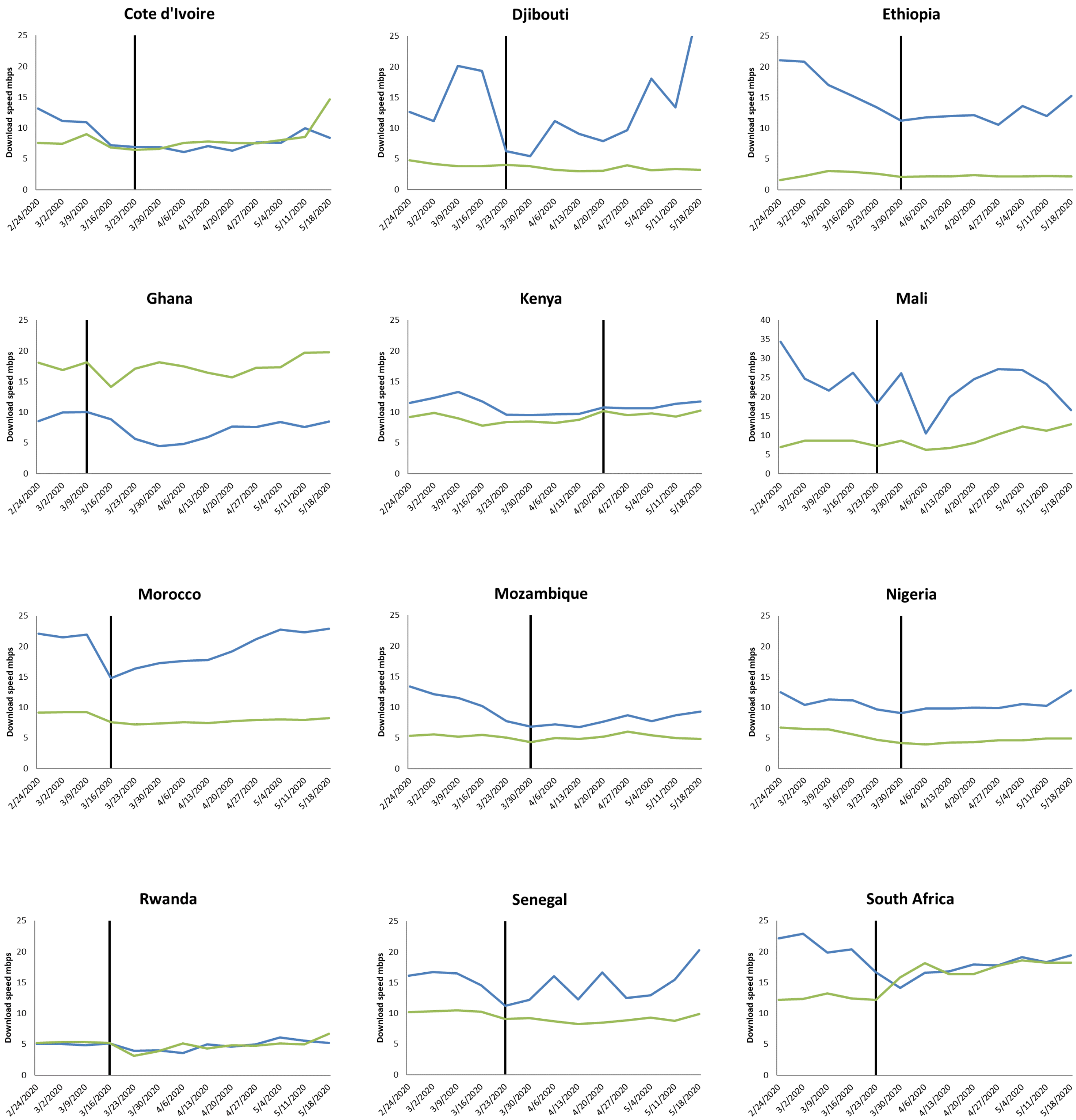
WHAT WERE THE OVERALL EFFECTS ON INTERNET SPEED?

Using descriptive statistics alone it is difficult to identify a specific pattern of recorded speed related to movement restriction orders in the sample of African countries. Some countries such as Cape Verde, Djibouti, Ethiopia, Morocco, Mozambique, Senegal, South Africa and Tunisia reported a declining trend before the "shelter in place" orders, only to recover speed in the following weeks. This may be attributed to the fact that some of the activities were already shifted to a remote basis in anticipation of the official governments' measures, based on global lockdown measures that had already transpired. In other countries such as Senegal, it was difficult to spot a trend related to the COVID-19 crisis.

The country graphs in Figure 4 report the median mobile (blue line) and fixed (green line) download speeds (mbps) recorded by the Ookla Speedtest between the 24th February and 23rd May 2020.[32] The black vertical line indicates the week in which lockdowns were implemented. Overall, the graphs show that the impact of the lockdown on mobile internet speed was much more pronounced than for fixed internet speed for most countries. This may be related to the underlying infrastructure of the two technologies. Mobile connectivity relies on cellular towers designed to sustain a certain capacity. Network upgrades are possible but require time and are also linked to external factors such as spectrum allocation. Fixed connectivity on the other hand tends to be more stable as the bandwidth is usually higher; hence, a shock in traffic can be sustained relatively better.

FIGURE 4: Timeline for fixed (green) and mobile (blue) internet speed before and after mandated lockdowns (black vertical line)




Cote d'Ivoire
Djibouti
Ethiopia
Ghana
Kenya
Mali
Morocco
Mozambique
Nigeria
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Senegal
South Africa
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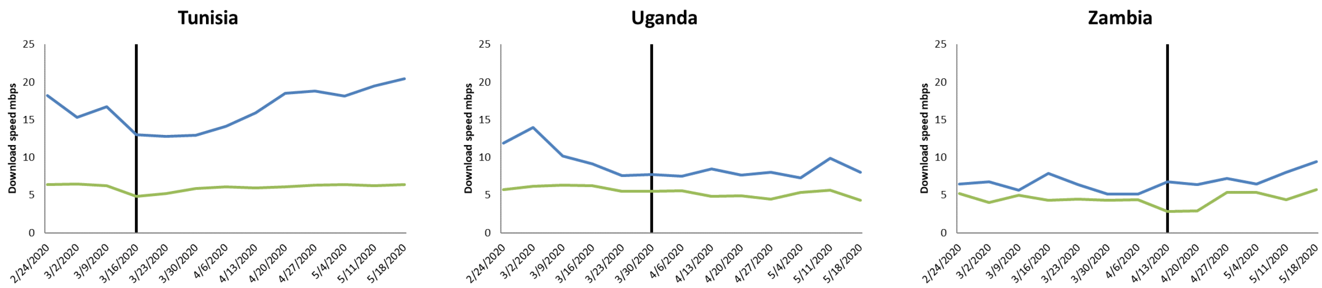
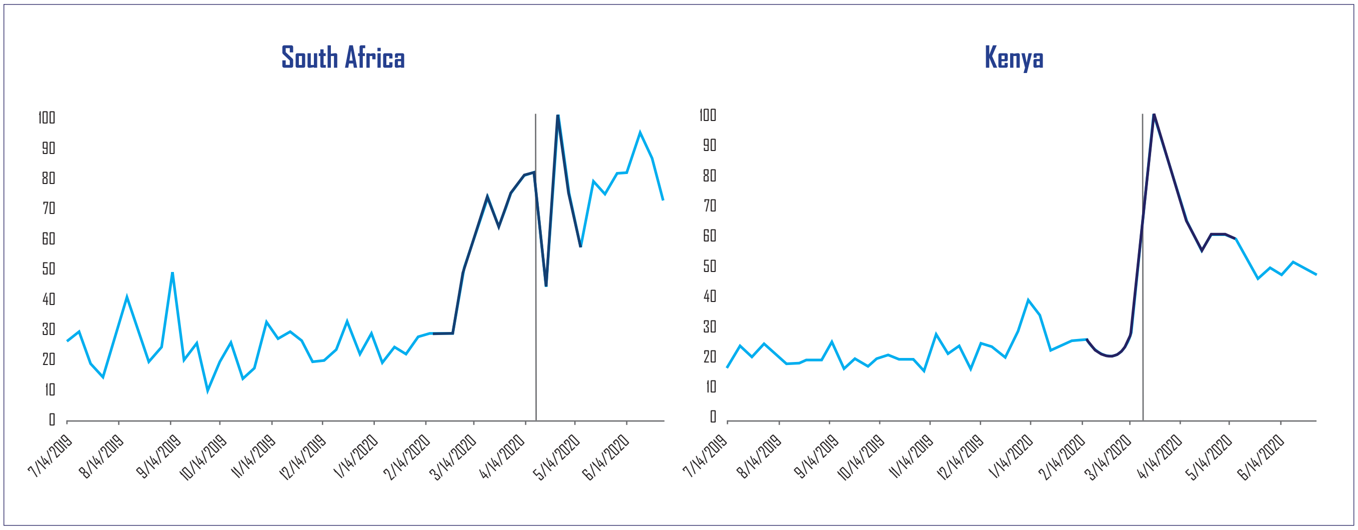


WAS THE IMPACT ON INTERNET SPEED SIGNIFICANT?

To estimate the impact of lockdown measures on mobile and fixed download speed, a before and after analysis was applied to check for any significant difference in speed and number of tests.[33] [34] Users' willingness to check speed is higher for different reasons. They could feel service quality had decreased, or they could also be using the tool to check where Wi-Fi signal is strong enough to perform certain activities (e.g. videocalls) or when users need good internet connectivity in a location where it had not previously been necessary.

The first step of the analysis consisted of analyzing the number of tests taken by users in the sample.[35] To do so the sample was divided between pre- and post-lockdown weeks. The findings show an increase in number of tests taken in the week of the lockdown and in the following weeks for both networks. The number of tests run by users on the fixed network increased on average by 12% after the lockdown measures. A similar finding was observed with mobile networks, where there was an average increase of 18% in speed testing. In both cases, an increase in download speed was negatively associated with the total number of tests. This suggests that users are more likely to check their internet speed when experiencing poor network performance. The increased number of tests reported by the data is also confirmed by Google Trend data, which reported a spike of "internet speed test" queries on their search engine for some of the countries in the sample, as illustrated in Figure 5.

FIGURE 5: South Africa and Kenya "internet speed test" Google searches



Note: A value of 100 is the peak popularity for the term. Red indicates the period of weeks represented in the dataset. The black vertical line reports the week in which a lockdown period commenced.

Source: Google

The next step of the analysis consisted of analyzing the download speed in the weeks pre- and post-lockdown. Results for the fixed networks indicate that after the lockdown, operators experienced an average decrease in download speed by 5%. Results for the mobile network were more acute as median download speed decreased on average by 17%.[36]

To get a more granular picture of what happened, the impact 1-3 weeks before and after the lockdown was estimated on a weekly basis. The results show statistically significant decreases in the median fixed download speed in the first and third week following "stay at home" orders. As expected, the impact is larger in the first week (10%) than the third week (6%). Similar results were observed with mobile networks in the weeks post-lockdown, with a higher decrease (26%) in the first week after the "stay at home" orders.

Finally, the country level effects were analyzed. The findings presented in Table 3 demonstrate that most of the countries in the sample experienced a decrease in the median download speed.[37] Tunisia and Uganda reported statistically significant results for the fixed network analysis. Both countries experienced a decrease in download speed in the post lockdown weeks by 8% and 25% respectively. With regards to the mobile network, Cote d'Ivoire and Nigeria reported statistically significant results. Both countries experienced a decrease in mobile median download speed in the post-lockdown weeks by 38% and 9% respectively.

TABLE 3: Results by country

COUNTRY	FIXED SPEED COEFFICIENT	P VALUE	MOBILE SPEED COEFFICIENT	P VALUEW
Angola	-.13	0.453	+.09	0.628
Burkina Faso	-.15	0.105	+.03	0.912
Cape Verde	-.32	0.417	-.28	0.578
Cote d'Ivoire	+.35	0.180	-.38***	0.003
Djibouti	-.13	na	-.35	na
Ethiopia	-.09	na	-.34	na
Ghana	-.14	0.107	-.23	0.317
Kenya	+.05	0.103	-.09	0.200
Mali	+0.00	0.963	-.16	0.519
Morocco	-.28	0.327	-.13	0.068
Mozambique	-.07	0.491	-.39	0.268
Nigeria	-.13	0.084	-.09**	0.012
Rwanda	+.02	0.896	-.37	0.344
Senegal	-.14	0.129	-.27	0.264
South Africa	+.25	0.099	-.28	0.113
Tunisia	-.08***	0.001	-.02	0.725
Uganda	-.25**	0.040	-.16	0.265
Zambia	+.09	0.488	+.21	0.133

WHAT DO THESE FINDINGS SUGGEST FOR THE DIGITAL INFRASTRUCTURE DEVELOPMENT AGENDA AND FUTURE STAKEHOLDER COLLABORATION?

The findings of this study not only demonstrate the resiliency of digital infrastructure in Africa, but also highlight and reflect the benefits of partnership between public and private stakeholders to manage traffic surges. The development community should leverage these partnerships to achieve the ambitious objective of universal access to the internet.

Irrespective of COVID-19, it's worth re-emphasizing that the recorded speeds in this sample of African countries lag significantly behind OECD standards. Good quality broadband should provide an average download speed of 10Mbps.[38] In the developing countries surveyed however, the average weekly median download speed of several countries did not reach this threshold.[39] To improve the current scenario, stakeholders should devote efforts and investments to those elements of the digital infrastructure which play a key role in reducing latency and improving speed.

The overall digital supply chain of emerging countries would benefit from an upgrade of fiber backbone networks that would generate positive effects on both mobile and fixed segments. For instance, radio base stations would improve performance if they were connected to fiber instead of microwave. Increasing the fiber backbone and backhaul in a country is an expensive investment, however, that usually requires multiple actors and significant stakeholder engagement. Public-Private Partnerships (PPP) are a useful mechanism for supporting this stakeholder collaboration. They have been used in both developing (e.g. Tanzania) and developed (e.g. United Kingdom) regions to facilitate digital connectivity. However, their success depends on a regulatory environment that promotes and enforces competition throughout the overall supply chain.[40]

Internet speed is also affected by the infrastructure in place to exchange data between different operators. The IXPs discussed earlier in this note have a direct impact on speed for end users.[41] The establishment of well-functioning IXPs requires a competitive retail market and an efficient regulatory environment which promotes best practices for IXP governance.[42] This is another example where the collaboration between different stakeholders (e.g. internet service providers, content providers, regulators) is key to the successful realization of a better digital infrastructure.

From a fixed infrastructure perspective, it is particularly important for emerging countries to improve last mile access. In fact, the deployment of a robust fiber backbone would not realize all its benefits if the last segment of the connection to end users was not supported by cable or fiber. Additionally, the promotion of competition and a fair regulatory environment are necessary elements to incentivize investments in this area. For instance, depending on the country circumstances, measures such as local loop unbundling could be advocated.[43]

The mobile segment in developing countries also requires significant improvements to reach the standard of more advanced economies. Different measures can be adopted to enhance network performance.[44] Firstly, the release of more spectrum at lower prices would allow mobile network operators (MNOs) to deliver more capacity. This is particularly relevant for 5G deployment, which carries a much larger volume of data at a much higher speed compared to 3G and 4G.[45] A study from the GSMA[46] shows how spectrum prices in emerging countries are on average more than three times higher compared to those in advanced economies. The report also highlights the link between high spectrum price and low upload and download speed, which the authors explain are the result of less investment devoted to network quality in light of spectrum fees.

Secondly, encouraging the shift to the latest technologies such as 4G and 5G will have an impact on speed. Developing economies are characterized by a higher level of 3G connections. For instance, 3G connections represent 42% of market penetration in Africa compared to 15% for 4G. These figures are partially explained by a lower population coverage; in Africa only 54% are within the reach of a 4G signal while almost 85% receive a 3G signal.[47] Hence, a higher density of mobile towers supported by 4G or 5G technology is needed to make sure networks are able to deliver target speeds. Infrastructure sharing may help address the high investment costs required to upgrade the network. Infrastructure sharing can take place at different levels,[48] affecting various segments of the digital supply chain. As with other suggested measures, an appropriate regulatory environment that facilitates infrastructure sharing is also needed to help markets deliver efficient outcomes for consumers.

CONCLUSION

Like the pandemic itself, the resulting surge in internet traffic was an unexpected event. According to the Telefonica CTO, internet consumption grew in two days by the same amount expected for all of 2020.[49] However, most of the telco providers were prepared to deal with the amount of data exchange they experienced in the following weeks and months. Many other network industries that would have experienced the same surge in usage could have risked collapse. From electricity grids to roads, most infrastructure is ill-prepared to sustain a similar prolonged spike in usage. During COVID-19 however, both the resilience of physical telecom networks, as well as the measures implemented by various stakeholders, proved to be remarkable in managing the traffic shock.[50]

For the 18 African countries explored in this study, the findings show a modest decrease in internet speed for both fixed and mobile networks, which are more pronounced for the latter. These findings are in line with what is emerging from the analysis on network resiliency.[51] However, country level results were statistically insignificant for a number of countries, possibly due to factors other than the lockdown measures that could explain changes in speed such as network optimization and public policy measures such as extra spectrum allocation. At the same time, the findings show that requests for checking internet speeds increased, suggesting that internet users may have experienced some decline in quality.

Further research is needed due to the scope of data collection and limits of the findings. Selection bias may have also affected the findings. For instance, a certain level of digital literacy is required to be aware of online internet speed tests and know how to perform them. This is more likely to manifest in the highest income segments of the population which are more likely to have access to better performing networks. Hence, there is a risk that this study underestimated the effect of lockdown measures on the overall internet user population. At the same time, users experiencing bad connectivity may have more incentives to check speed compared to those receiving good service, resulting in data that reflects a worse scenario than what actually transpired on the ground. Future research should build on the findings from this study by integrating more detailed information on the network optimization strategies implemented by providers in order to isolate the specific effect of lockdown measures on speed. Future studies should also include a deeper analysis of all the policy initiatives promoted by regulators to improve network quality to yield more granular insight into their impact on network speed and resilience.

The COVID-19 crisis highlighted that to untap the potential of digital technologies, access to the internet may not be enough. Remote activities such as learning and working require a minimum level of speed to perform certain tasks. It is crucial that users can leverage all the opportunities available through the internet; to do so, service quality must be improved. COVID-19 will be a game changer for the entire global economy and the digital sector will play a central role in defining the so-called "new normal." As this global transformation takes shape, it is important that no one is left behind. International organizations, the private sector and local regulators should all work together to make sure users have access to an affordable and reliable connection. The risk of not accomplishing this objective is to not only impede progress towards SDG 9c, but also further widen the inequality gap between advanced and emerging economies.

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5 Angola, Burkina Faso, Cape Verde, Cote d'Ivoire, Djibouti, Ethiopia, Ghana, Kenya, Mali, Morocco, Mozambique, Nigeria, Rwanda, Senegal, South Africa, Tunisia, Uganda and Zambia.

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27 Data are unbalanced among the sample as the number of providers vary by segment (fixed or mobile) and geography; the same applies to the number of tests. Also, the decision to undertake a speed test is self-selecting by the user and is therefore not representative of the experience of the user base as a whole. For instance, checking internet speed requires a certain level of digital literacy. At the same time, speed tests may be run more intensively by those users who experience (or perceive) poor network performance. Hence, the analysis may reflect this data bias.

28 Based on analysis by Ookla® of Speedtest Intelligence® data for the week of the 24th February 2020. Ookla trademarks used under license and reprinted with permission.

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32 Based on analysis by Ookla® of Speedtest Intelligence® data between the 24th of February and the 23rd of May, 2020.

33 Research of local news stories helped identify when lockdown periods took place in different countries. Both "stay at home" orders and curfews were considered.

34 Data was treated as a panel where the two dimensions were the single providers and the weeks. All the regressions were run with fixed effects to capture time invariant characteristics of the providers. Depending on the different model's specifications, the panel was divided in weekly dummies or post-lockdown dummy, the latter taking the value "0" for the weeks before the lockdown and "1" afterwards. The equations that delivered the results presented in this note were estimated separately for the fixed and mobile observations, as noted below.

a) (log) Number of tests = constant + (log) download speed + post lockdown dummy + error
b) (log) Download speed = constant + weekly dummies + error
c) (log) Download speed = constant + location*post-lockdown dummy + error

Where results are presented in percentage terms is due to variables being transformed in logarithms.

35 If a user took multiple tests, it still counted as one.

36 Estimations include panel fixed effects and robust standard errors.

37 :*** p<0.01, ** p<0.05, * p<0.1. Not available (na) p values are due to the limited number of observations.

38 Broadband Commission for Sustainable Development. 2019. "Connecting Africa Through Broadband. A strategy for doubling connectivity by 2021 and reaching universal access by 2030".

39 6 countries for the mobile segment and 14 in the fixed segment reported very low figures.

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42 Comini and Srinivasan, 2020, "National Data Infrastructure, The Role of Internet Exchange Points, Content Delivery Networks and Data Centers", WDR2021 Background Paper, forthcoming.

43 Klein, Gordon and Wendel, Julia, "The impact of local loop and retail unbundling revisited," No 163, DICE Discussion Papers, University of Düsseldorf, Düsseldorf Institute for Competition Economics (DICE), https://EconPapers.repec.org/RePEc:zbw:dicedp:163, 2014.

44 E. J. Oughton et al., "Open-Source Techno-Economic Assessment Framework for 5G Deployment", 2019.

45 GSMA, Introducing Radio Spectrum, 2017.

46 GSMA, Spectrum Pricing in Developing Countries, 2018.

47 GSMA data, 2020.

48 GSMA, Infrastructure Sharing: An Overview, Future Networks, 2019.

49 For instance, the Cape Verde Multisector Regulatory Agency (ARME) decided to allocate additional spectrum to mobile communications operators – at no additional cost – to meet the surge in demand for traffic of voice and data and also to ensure a minimum service quality. See https://www.nytimes.com/2020/03/26/business/coronavirus-internet-traffic-speed.html

50 https://www.arme.cv/index.php?option=com_content&view=article&id=528:covid-19-arme-emite-recomendacoes-e-fixa-medidas-excecionais-para-sectores-regulados&catid=79&Itemid=878

51 See for instance https://www.ey.com/en_gl/telecommunications/is-your-risk-radar-tracking-the-right-threats-in-the-new-normal

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