CONSULTING

REPORT FOR FACEBOOK

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THE IMPACT OF FACEBOOK'S CONNECTIVITY INITIATIVES IN SUB-SAHARAN AFRICA

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1 Executive summary

Facebook has launched a range of initiatives aimed at tackling the barriers to connectivity, by investing directly in infrastructure and partnering with telecoms operators and Internet service providers to improve connectivity. We estimate that the economic benefits to sub-Saharan Africa stemming from Facebook's connectivity initiatives may exceed USD50 billion over the next five years.

Access to the Internet is increasingly important throughout the world as a means for people to communicate, learn, work, trade and participate fully in everyday life. People use the Internet to access content and services that can be provided from anywhere in the world, allowing connections between friends, strangers, businesses and customers that were unimaginable a generation ago. These connections are achieved through an interconnected web of networks that enable information to be exchanged between a shopkeeper in Kinshasa, a supplier in Seoul and a customer in Maputo.

The infrastructure required to provide this connectivity is relatively scarce in sub-Saharan Africa compared to other regions of the world. This reflects the difficulty of making a return on investment in places where incomes are low, and where people may be unaware of the benefits the Internet could bring them and may not have the skills to use online services. This lack of availability of infrastructure creates its own barrier to people getting online, and is compounded by issues related to affordability, relevance and readiness of people to get online.

In response, **Facebook has launched a range of connectivity initiatives aimed at tackling these barriers,** by providing financial and technical inputs that can make infrastructure easier and cheaper to deploy. These initiatives contribute to Facebook's mission "to give people the power to build community and bring the world closer together", by using applications and online services provided by Facebook and other providers, accessing the wealth of content available on the Internet, and creating their own content and services. These initiatives fall broadly into two categories.

First, **Facebook invests in network infrastructure,** either directly or through long-term contracts. These investments include **fibre investment under the OTNx umbrella** (currently deployed in Nigeria and Uganda), **edge network infrastructure** including points of presence in Kenya, Nigeria and South Africa, and caches in operators' networks in 44 sub-Saharan African countries. Facebook is also investing in submarine cables such as the recently announced 2Africa cable[1] and data centres (currently none in Africa).

Second, **Facebook has developed programmes through which it works closely with telecoms operators and Internet service providers to improve connectivity,** typically using innovative platforms and technologies that can improve the economics of network deployment and operation. These initiatives are primarily focused on access network infrastructure and aim to support operators and service providers in bringing more people online by extending network coverage and improving service affordability. In sub-Saharan Africa, these initiatives include **Express Wi-Fi,** an end-to-end SaaS platform for launching and operating a sustainable, high-quality Wi-Fi network, through a Facebook-designed interface and workflow, onto an operator's public Wi-Fi network. It is available in Ghana, Kenya, Malawi, Nigeria, Senegal, South Africa and Tanzania, helping to bring more people online and stimulating data usage and Internet traffic overall. Facebook is also working on initiatives under the **Rural Access** umbrella, which focus on reducing the costs of rolling out broadband in less populated and poorer rural areas.

These initiatives create socio-economic benefits for consumers, businesses and governments throughout sub-Saharan Africa. **Individuals** benefit through increased access to information and services, which leads to improved quality of life, health, education and income. **Businesses** benefit from increased organisational efficiency and ease of reaching and communicating with customers. Finally, **governments** can use better connectivity to boost efficiency and transparency, as well as increasing the reach and quality of e-government services.

[1] On 14 May 2020, after this report was completed, Facebook along with seven partners announced a new submarine cable called 2Africa that will connect 23 countries in Africa and MENA, and increases Facebook's investment in infrastructure in Sub-Saharan Africa. However, for the purposes of this report, 2Africa is not included and is not reflected in the results.

Quantifying these impacts is fraught with difficulty, but economic and econometric studies (by the ITU in Africa in 2019, and by GSMA and Deloitte in 2012) provide an indication of how increased Internet take-up and usage translate into productivity and consumption, with an impact on GDP. In sub-Saharan Africa, where connectivity challenges remain high and Internet usage is still limited to a minority of people, even modest improvements can have a significant effect on outcomes.

We estimate that the **economic benefits to sub-Saharan Africa stemming from Facebook's connectivity initiatives can exceed USD50 billion** over the next five years (2020–2024), in nominal current GDP terms.[2] The biggest impact by far is linked to Facebook's investment in international capacity and edge infrastructure, which allows operators to offer much more data to end users, and benefits all Internet users (nearly 500 million people by 2024). Facebook's initiatives with operator partners (Express Wi-Fi and OTNx, primarily) are enabling millions of people to get online earlier than they would have otherwise, with OTNx already helping to extend broadband coverage to 4 million people in Uganda and Nigeria. The estimated economic benefits derived from Facebook's various connectivity initiatives is shown in Figure 1.1 below.

FIGURE 1.1: ESTIMATED CUMULATIVE IMPACT OF FACEBOOK CONNECTIVITY INITIATIVES, 2020–2024
[SOURCE: ANALYSYS MASON, 2020; ALL VALUES IN NOMINAL USD AT PROJECTED CURRENT EXCHANGE RATES]

Source of impact	Drivers of impact	Cumulative 2020–24 GDP impact, USD billion
OTNx	High-speed Internet take-up	3.9
Edge networks and submarine cables	Internet traffic / data usage	53.4
Express Wi-Fi	High-speed Internet take-up and Internet traffic / data usage	0.3
Total		**57.6**

Beyond infrastructure and connectivity initiatives, Facebook is also working on improving the economics of network equipment through the Telecom Infra Project, or TIP, and is driving some of these initiatives together with partners (Terragraph, OpenCellular). Whilst these initiatives are not widespread yet in sub-Saharan Africa, they offer the prospect of cheaper, more widely accessible and affordable broadband for all. Facebook is also working to reduce barriers to end-user demand for online services, through Free Basics, one of the most extensive localisation efforts undertaken online, as well as its 'Data for Good' initiatives.[3]

Whilst these initiatives all contribute greatly to a better Internet, and make it accessible and affordable to more people in sub-Saharan Africa than ever before, they are only part of a complex solution that requires all stakeholders – including operators, Internet companies and governments – to work together for the common good.

[2] This represents the overall impact of initiatives with Facebook's involvement, however some of these initiatives rely on contributions from operator partners as well as Facebook.

[3] Demand-focused initiatives are not the subject of this report, but some case studies providing more detail on these initiatives and their impact are included in Annex B. Free Basics aims to help people discover the relevance and benefits of connectivity by providing free access to basic online services; Facebook supported over 111 languages in 2019; Data for Good initiatives include the Crisis Communication Response Program (CCRP) which aims to ensure efficient connectivity in crisis conditions.

THE IMPACT OF FACEBOOK'S CONNECTIVITY INITIATIVES IN SUB-SAHARAN AFRICA

800 million people across sub-Saharan Africa are not Internet users due to various barriers to connectivity

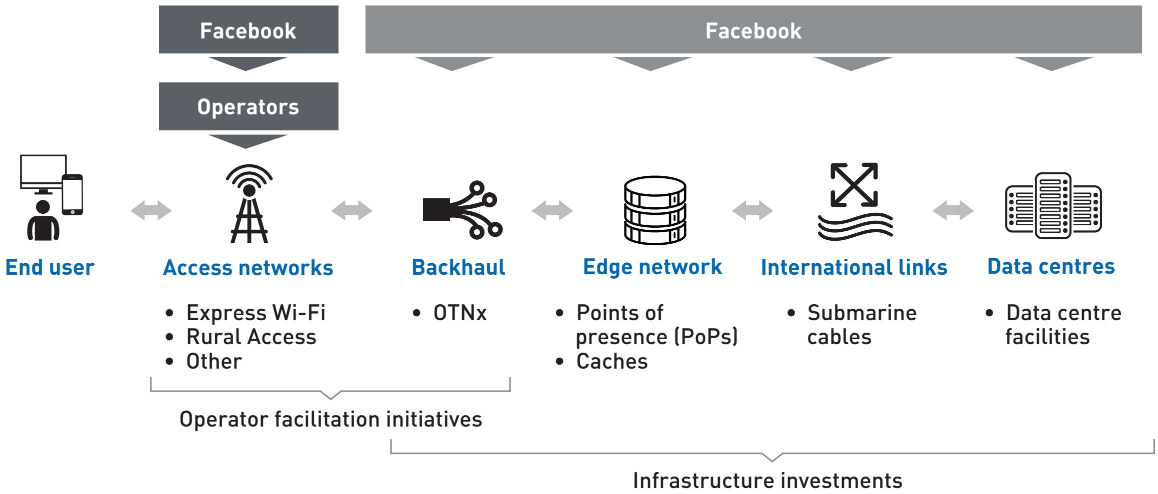
Availability
Broadband networks (e.g. 3G) are only available to 71% of the population

Relevance
All but five countries in sub-Saharan Africa rank in the lowest quartile on local and relevant content

Affordability
1GB of monthly data accounts for ~8% of average income (vs 2% UN target)

Readiness
38% of adults lack literacy skills and many are not familiar with digital technologies

To address these barriers, Facebook is investing in initiatives across the entire connectivity value chain



These initiatives generate economic impact in sub-Saharan Africa through improving connectivity outcomes in the region

Initiative	**Express Wi-Fi**[2]	**Fibre backhaul**	**Edge networks and submarine cables**
Connectivity impact	Launched in 7 countries in sub-Saharan Africa	4 million people covered with 3G+ service in Uganda and Nigeria	Facebook apps are estimated to account for ~20% of total Internet traffic in the region, and 70% of Facebook traffic is served from within the region
Economic impact, 2020-2024[1]	USD0.3 billion	USD3.9 billion	USD53.4 billion

Total 2020-2024 economic impact: USD57.6 billion

[1] Economic impact denotes cumulative nominal GDP impact of Facebook's initiatives over 2020-2024; we note that this includes only the effects that could be quantified

[2] Express Wi-Fi is an operator facilitation initiative, i.e. infrastructure deployment is carried out by local partners; Facebook does not deploy or operate access networks

2 The connectivity value chain and barriers to connectivity

Connecting to the Internet requires many connections to be made, often spanning whole countries or continents and multiple networks. The end user's device must connect to the network of an internet service provider (ISP), through a physical medium that can be a cable (made of copper or optical fibre) or a wireless signal (cellular or Wi-Fi). The ISP then manages the exchange of information between users and online service and content providers over infrastructure at local, national and international levels. The infrastructure and the value chain that enable this exchange of information, at high speed and on a massive scale, are complex and depend on sustained investment from many market participants. This 'connectivity value chain' is described in Section 2.1.

In sub-Saharan Africa, the infrastructure that is available to provide this connectivity lags behind that in more developed world regions. This reflects the difficulty of making a return on investment in places where incomes are low, and where people may be unaware of the benefits the Internet could bring them and may not have the skills to use online services. This lack of availability of infrastructure creates its own barrier to people getting online, and is compounded by issues related to affordability, relevance and readiness of people to get online. The barriers to connectivity and their relationship to this value chain are explored in Section 2.2.

Section 2.3 introduces the initiatives that Facebook has launched in order to help tackle these barriers, by providing financial and technical inputs that can make infrastructure easier and cheaper to deploy.

2.1 Internet connectivity relies on a complex chain of networks and relationships

When end users access the Internet, they communicate with computers, devices and people that are also connected to the Internet, often on different networks, in different countries or even continents. In many cases, end users communicate with computers hosted in large data centres, which provide the services and host the content that users want to access or contribute to. This content travels between end users and the servers of the online service or content provider across a 'connectivity value chain' (shown in Figure 2.1), consisting of various types of infrastructure, each of which includes a challenge to be overcome in sub-Saharan Africa.

FIGURE 2.1: CONNECTIVITY VALUE CHAIN [SOURCE: ANALYSYS MASON, GSMA INTELLIGENCE, EUROMONITOR,[4] 2020]

Value chain element	End user	Access networks	Backhaul	Edge network	International links	Data centres
Description	**End users** access the Internet using browsers and applications on their devices, sending and receiving data across the connectivity value chain	**Access networks** provide the final connection to end users • mobile access networks may use different technology generations (2G, 3G, 4G, 5G) and send wireless signals to mobile devices or to fixed-wireless access (FWA) routers • fixed-line access networks may use copper or fibre-optic lines, with the latter offering higher connection speeds	**Backhaul** is the part of the network that provides connectivity from access networks to the core networks and the wider Internet. This may be high-capacity fibre cables, or use wireless technologies (e.g. microwave or satellite), depending on type of terrain, technical requirements, and cost considerations	**Edge network elements**, such as Internet exchange points (IXPs), points of presence (PoPs) and caches are used to create efficient peering links and to store content, minimising the distance that content needs to travel to reach the end user, thereby reducing the time required for the user's request to be processed (i.e. latency) and the cost of transporting data	**International links** such as submarine and terrestrial fibre cables connect remote geographies to deliver content between them	**Data centres** are facilities that store content and process data at large scale
Challenges in sub-Saharan Africa	Just 20% of people use the Internet, with various barriers impacting demand for connectivity services	Only 0.6% of people in sub-Saharan Africa have fixed-line broadband access. Mobile broadband access networks (3G or higher) cover just 77% of the population	There is a lack of fibre infrastructure in the region, and wireless backhaul can be unsuitable for high-speed broadband services	Edge networks are underdeveloped compared to other regions, which increases the cost and latency for ISPs to deliver content	There is limited capacity on existing submarine cables reaching Africa, and investment is needed to meet future demand	Content consumed online in Africa is typically hosted on other continents, requiring international links to transport the content between countries

[4] Data on share of people using the Internet (20%) and having access to fixed broadband (0.6%) in sub-Saharan Africa: Facebook, The Economist Intelligence Unit - Inclusive Internet Index 2019, see https://theinclusiveinternet.eiu.com/; Data on population coverage of 3G: calculated based on GSMA Intelligence and Euromonitor.

2.2 Over 800 million people in sub-Saharan Africa remain unconnected to the Internet due to a combination of challenges and barriers to connectivity

Through its sponsorship of the Inclusive Internet Index, Facebook consistently monitors the extent to which Internet services are available to, and being used by, people worldwide. The latest data, published in February 2020, shows that despite strong growth in Internet users nearly half of the world's population remains unconnected. In sub-Saharan Africa less than 20% of people use the Internet, leaving over 800 million people unconnected.[5]

Even among those people who do use the Internet in sub-Saharan Africa, many do not have access to 'meaningful connectivity', as speeds and data allowances are insufficient to access multimedia and other applications that make up a full Internet experience.[6] This is sometimes due to poor network performance (e.g. only having access to slow 2G networks), and sometimes because meaningful connectivity comes at a price that is too high for many people.

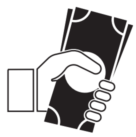
There are four broad categories of barrier to connectivity that prevent people from getting online:[7]

Availability

Many people do not have access to physical network coverage where they live. This primarily relates to access networks, although the commercial case for extending this coverage is impacted by other elements in the connectivity value chain, as discussed in Section 3.3.

Fixed broadband networks are not widely developed in sub-Saharan Africa, so mobile networks are the primary means of connectivity in the region. Mobile networks are unavailable to 9% of the region's population, with a further 20% only having access to low-speed (2G) mobile services,[8] which limits their ability to enjoy meaningful connectivity, that is to say connectivity services at a high enough speed to allow end users to access most of the content and services available on the Internet.

Affordability



Many people cannot afford Internet services or devices, or the amount of data and/or content that would make the connection meaningful.

Organisations such as the International Telecommunication Union (ITU), UNESCO Broadband Commission for Sustainable Development and the Alliance for Affordable Internet (A4AI) define Internet service as affordable if the price of 1GB of data equates to no more than 2% of gross national income (GNI) per capita;[9] A4AI's research shows that on average across the African continent, 1GB of data accounted for 8% of average income at the end of 2018 – compared to 2.7% in the Americas and 1.5% in Asia – highlighting that services are unaffordable for many in the region.[10]

[5] Facebook, The Economist Intelligence Unit - Inclusive Internet Index 2020, see https://theinclusiveinternet.eiu.com/

[6] A4Ai – "Meaningful Connectivity — a new standard to measure internet access", see https://a4ai.org/meaningful-connectivity-a-new-standard-to-measure-internet-access/

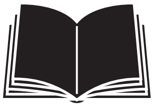
[7] The four barriers were introduced in the State of Connectivity 2015 report, by Analysys Mason and internet.org by Facebook. These are consistent with classifications from other organisations, such as the GSMA, which defines barriers in terms of network coverage, lack of awareness and locally relevant content, lack of digital skills, and affordability. See: Connected Society Consumer barriers to mobile internet adoption in Africa, GSMA 2019. The World Economic Forum's Internet for All initiative also identifies similar barriers to Internet inclusion: infrastructure, affordability, skills, awareness and cultural acceptance, and relevant content. See: https://www.weforum.org/projects/internet-for-all

[8] GSMA Intelligence; Note: 2G enables access only to basic Internet services, and 3G is the minimum standard for meaningful broadband connectivity.

[9] Alliance for Affordable Internet – "Affordable Internet is 1 for 2", see https://a4ai.org/affordable-internet-is-1-for-2

[10] Alliance for Affordable Internet – 2019 Affordability Report; Quartz Africa news – "The cost of internet access is dropping globally but not fast enough in Africa", 21 March 2019. Note: 1GB per month is equal to 40 minutes' daily usage of web browsing and social media.

Relevance



While there is an abundance of online content and services, people may not see the available content as relevant, interesting or easy to understand.

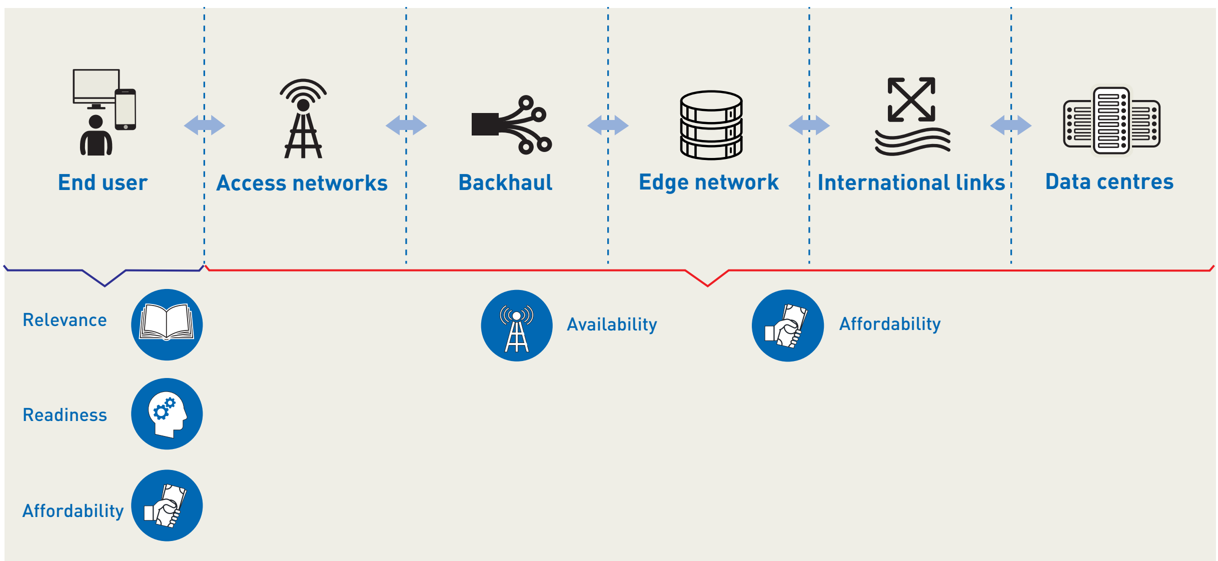
Given the linguistic and cultural diversity within sub-Saharan Africa, localised tailoring of content is an important consideration; according to the Inclusive Internet Index, sub-Saharan Africa generally scores below the global average on metrics that reflect the relevance of content (e.g. e-finance, e-health, e-commerce content ratings),[11] indicating that improvements are needed to create or adapt content so that it is seen as relevant by local populations.

Readiness

Many people lack the ability to enjoy meaningful connectivity, for a variety of reasons: 38% of adults in sub-Saharan Africa[11] have insufficient reading or writing skills to use online services, others lack the skills or confidence to go online, whilst many people are still not aware of what content and services they can access on the Internet, and how they can benefit from them. Internet users may also be reluctant to go online because of concerns around privacy and security.

Investment in infrastructure is key to addressing the *availability* barrier, and the cost of this infrastructure must typically be recouped through service pricing, which in turn impacts the *affordability* barrier. Operators and investors need to commit money to roll-out projects, for which they require a return that is commensurate with the risk they take. This return is hard to achieve when the infrastructure is expensive, risks are high and demand is uncertain. These challenges have restricted investment in sub-Saharan Africa, where costs are high due to the lack of existing road and power infrastructure, commercial risks may be significant due to political, macroeconomic and environmental factors, and demand from end users is negatively impacted by the affordability, relevance and readiness barriers (see Figure 2.2).

FIGURE 2.2: BARRIERS TO CONNECTIVITY ARISING ALONG THE CONNECTIVITY VALUE CHAIN [SOURCE: ANALYSYS MASON, 2020]



[11] Facebook, The Economist Intelligence Unit – Inclusive Internet Index 2020, see https://theinclusiveinternet.eiu.com/

2.3 Facebook is actively engaged in connectivity initiatives and investments aimed at reducing these barriers in sub-Saharan Africa and globally[12]

Facebook has launched a broad set of initiatives aimed at improving global connectivity, by helping to address barriers to affordability, relevance and readiness. The primary focus of this report is on Facebook's initiatives that aim to improve the supply of connectivity infrastructure, thereby addressing the *availability* and *affordability* barriers to connectivity. These connectivity infrastructure initiatives can be split into two categories, illustrated in Figure 2.3:

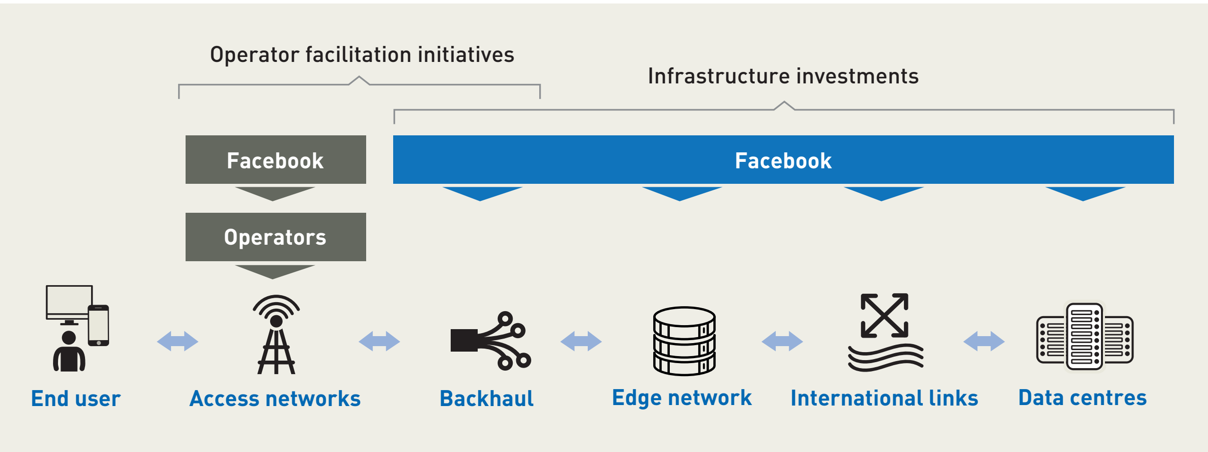
- **Investments in connectivity infrastructure –** Facebook invests in connectivity infrastructure, either directly or through long-term contracts. These investments are typically made alongside other investment partners and cover backhaul, edge network, submarine cables and data centres (discussed in Section 3).

- **Initiatives that support operator investments –** Facebook has developed programmes through which it works closely with local telecoms operators to improve connectivity, typically using innovative platforms and technologies that can improve the economics of network deployment and operation. These initiatives are primarily focused on access network infrastructure and aim to support operators in bringing more people online through extending network coverage and improving service affordability (discussed in Section 4).These initiatives are primarily focused on access network infrastructure and aim to support operators in bringing more people online through extending network coverage and improving service affordability (discussed in Section 4).

We examine the economic and social impact of Facebook's connectivity initiatives in Section 5.

Facebook has also undertaken some initiatives focused on barriers to end-user demand for online services. These include Free Basics, which aims to help people discover the relevance and benefits of connectivity by providing free access to basic online services, as well as efforts on localisation and language support to make Facebook applications more widely accessible. Furthermore, Facebook's 'Data for Good' initiative focuses on generating and disseminating data concerning humanitarian efforts, including the Crisis Communication Response Program (CCRP) which aims to ensure efficient connectivity in crisis conditions. These demand-focused initiatives are not the focus of this report, but some case studies providing more detail on these initiatives and their impact are included in Annex B.

FIGURE 2.3: TARGETING OF FACEBOOK INFRASTRUCTURE INITIATIVES ACROSS THE CONNECTIVITY VALUE CHAIN [SOURCE: ANALYSYS MASON, 2020]



[12] Facebook's initiatives in the ASEAN region are covered in detail in the related report, Analysys Mason for Facebook - The impact of Facebook's connectivity initiatives in the ASEAN region, 2020.

3 Facebook's infrastructure investments in connectivity

Direct infrastructure investments are projects in which Facebook contributes financially to infrastructure deployment through a variety of investment models. This section describes the types of infrastructure project that Facebook invests in (summarised in Figure 3.1), outlining the objectives and business models of these investments, and highlighting examples in sub-Saharan Africa.

To support the growth in the demand for content on Facebook's platforms (including Instagram and WhatsApp), Facebook is investing in building its own data centres. These are 'hyperscale' facilities[13] that enable efficiencies in power and cost compared to leasing space in smaller third-party data centres. As shown in Figure 3.2, most of Facebook's data centres are in the USA, with three in Europe (Ireland, Sweden, Denmark) and one under construction in Asia (Singapore).

Facebook does not have its own data centres in sub-Saharan Africa (and at the time of writing has not announced any plans to build one), much of the content consumed on Facebook originates from data centres outside sub-Saharan Africa.

This content must be carried into sub-Saharan Africa and other markets around the world, which has led Facebook to invest in submarine cables (Section 3.1). To improve network performance and economics for ISPs, Facebook is investing in edge network elements such as IXPs[14], PoPs and caches that help bring content closer to end users (Section 3.2). Finally, to support the extension of broadband access networks to provide coverage to more end users, Facebook is also investing in fibre backhaul infrastructure (Section 3.3).

FIGURE 3.1: SUMMARY OF FACEBOOK INFRASTRUCTURE INVESTMENTS [SOURCE: ANALYSYS MASON, 2020]

	Facebook investments
	Facebook invests in a small number of global hyperscale **data centres,** which are used to serve all world regions; including sub-Saharan Africa, via international links and the edge network described below
	Facebook invests in **international links** such as submarine and terrestrial fibre cables.
	Facebook invests in **edge network** elements, such as IXPs, PoPs and caches. It has three PoPs and at least one cache in 44 countries in Africa.
	Facebook has invested in fibre **backhaul infrastructure**.To date it has supported deployment in Uganda and Nigeria.
	Facebook does not invest directly in deploying **access network** infrastructure, but aims to stimulate investment through operator facilitation initiatives (Section 4).

[13] The term hyperscale typically refers to very large data centres with hundreds of megawatts of capacity, built by online service providers such as Facebook, Amazon, Microsoft, and Google.

[14] Note: Facebook does not invest in IXPs directly but rather supports their development by third parties.

FIGURE 3.2: FACEBOOK'S GLOBAL DATA CENTRES [SOURCE: BAXTEL, PRESS SEARCH, ANALYSYS MASON, 2020]

3.1 Submarine cable investments reduce the need for operators to invest in international connectivity

Submarine cables are designed to transport data over short and long distances, using international fibre links laid along the seabed between and around continents. Facebook is a major purchaser of capacity on cables serving sub-Saharan Africa, using this capacity and routes to transport content to its three regional PoPs, in Kenya, Nigeria and South Africa.

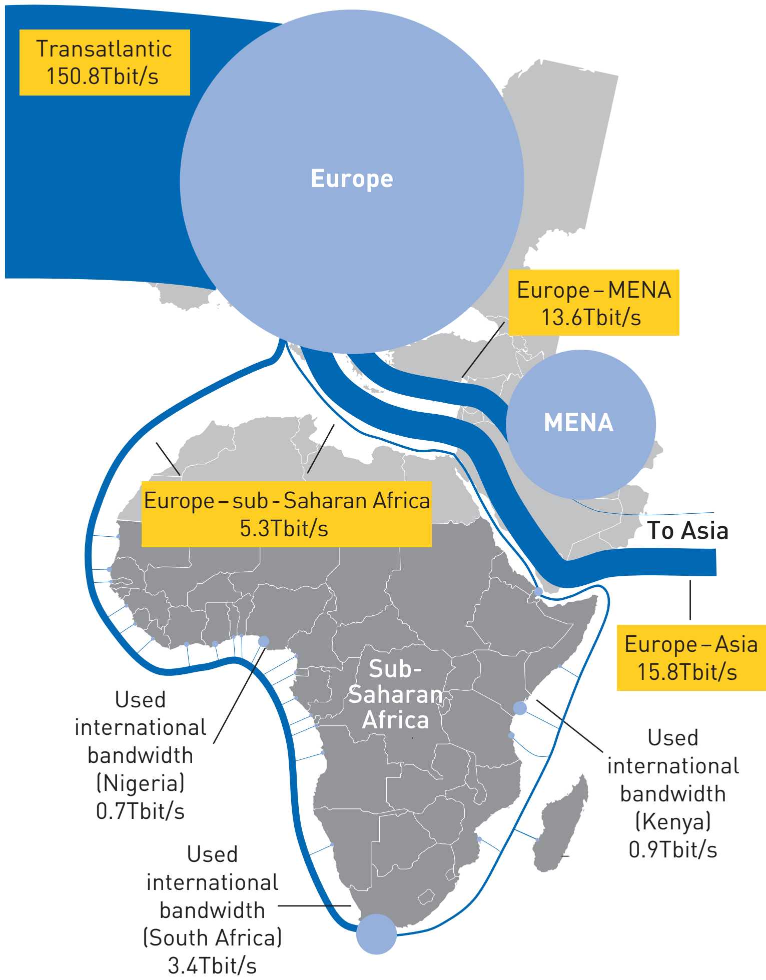
There are currently 18 existing and planned submarine cables connecting to sub-Saharan Africa, but these cables have finite capacity and further investment is required to support future growth in demand for international capacity. Over 80% of international capacity serving sub-Saharan Africa connects to Europe, a route which carried 5.3Tbit/s of traffic in 2018 (significantly lower than traffic between other regions – see Figure 3.3). This traffic is forecast to grow by over 40% per year on average over the next five years, reaching 42Tbit/s by 2024.[15]

Although the supply of submarine capacity to sub-Saharan Africa has increased in response to this trend, with new cables being planned and deployed, further investment is needed if supply is to keep pace with the rapid growth in demand for international capacity. In the meantime, the relatively limited submarine capacity landing in Africa results in high prices for bandwidth on the continent, especially for the landlocked countries that require additional cross-border terrestrial fibre connectivity to reach the submarine cable landing stations. While an ISP in London may have been able to buy IP transit services for around USD0.25 per Mbit/s per month in mid-2019, the equivalent service in Johannesburg (South Africa) cost over ten times as much (USD3 per Mbit/s per month), and in landlocked Kampala (Uganda) it was higher still at USD10 per Mbit/s per month.[15]

By acting as a major customer for international capacity, Facebook is supporting investment in new cables. However, with the growth of Facebook's global demand for international connectivity, it has started to supplement its purchase of capacity on third-party cables by investing directly in new submarine cables as part of consortia. To date, Facebook has announced partial ownership of nine submarine cables around the world, including a number of cables that have not yet been launched, as summarised in Figure 3.4.

[15] Note: Facebook does not invest in IXPs directly but rather supports their development by third parties.

FIGURE 3.3: GLOBAL INTERNATIONAL BANDWIDTH USED BY ROUTE IN 2018 [SOURCE: TELEGEOGRAPHY, ANALYSYS MASON, 2020]



Where Facebook invests as part of consortia, the new submarine cables carry traffic not only for Facebook and its consortium partners, but also for other parties that purchase or lease capacity on the resulting infrastructure through long-term contracts. By increasing the supply of submarine capacity available at multiple landing points, these investments reduce the price of capacity for ISPs, which results in a combination of better broadband services and lower prices for end users, increasing the quality and affordability of broadband services over time.

Investment in new cables can also create new routes, which can be used to improve the number and diversity of paths used to carry traffic within a region, and to and from other regions. This enhances service reliability when a cable experiences faults and reduces the cost and the latency of links to newly connected locations compared to existing routes.[16]

Facebook's involvement in these projects can ensure that the deployment takes place, as evidenced by interviews with Facebook which revealed that in several Asian submarine cable projects, Facebook increased its investment share following a last-minute exit by a consortium partner.

On 14 May 2020, after this report was completed, Facebook along with seven partners announced a new submarine cable called 2Africa that will connect 23 countries in Africa and MENA, and increases Facebook's investment in infrastructure in Sub-Saharan Africa. However, for the purposes of this report, 2Africa is not included and is not reflected in the results.

[16] Latency is a measure of the delay between a request being made by one user and it being received by another user. Lower latency results in a more responsive experience, which has been associated with greater user satisfaction and higher demand.

FIGURE 3.4: FACEBOOK'S DIRECT INVESTMENTS IN SUBMARINE CABLES ANNOUNCED AS OF 2019 [SOURCE: TELEGEOGRAPHY, FACEBOOK PRESS RELEASES, ANALYSYS MASON, 2020. NOTE: TARGET READY FOR SERVICE DATES MAY BE SUBJECT TO CHANGE]

Cable system	Route	Target ready for service	Design capacity
APG	Intra-regional (APAC)	2016	58Tbit/s
MAREA	Trans-Atlantic	2018	208Tbit/s
Havfrue	Trans-Atlantic	2020	144tBit/s
PLCN	Trans-Pacific	2020	126Tbit/s
SJC2	Intra-regional (APAC)	2020	126Tbit/s
Jupiter	Trans-Pacific	2020	60Tbit/s
HKA	Trans-Pacific	2020	77Tbit/s
Malbec	Intra-regional (LATAM)	2020	N/A
BtoBE	Trans-Pacific	2021	108Tbit/s

3.2 Edge network investments allow ISPs and MNOs to access content on Facebook's platform at locations closer to their own networks, at much reduced costs

The term 'edge network' refers to infrastructure that enables the processing, transfer or storage of data at distributed locations around the periphery of a network, rather than in a small number of centralised data centres. Facebook has been investing in its internal network (or 'production network') with the aim of maximising efficiency and minimising costs associated with delivering content by enabling ISPs and MNOs to access and exchange content within the sub-Saharan region, rather than further afield. This reduces costs for the MNOs and ISPs as well as improving the performance of Facebook applications and the user experience. To achieve this, Facebook is investing across a variety of network elements, including points of presence (PoPs), caches and IXPs.

- **Points of presence (PoPs):** locations where ISPs can interconnect with the Facebook internal network (typically through peering arrangements, as explained in the box below) and access all of its content, with reduced cost and latency compared to accessing this content in other regions
- **Caches:** servers deployed within a country that store popular content of a static nature (such as videos and pictures)[17] that can then be delivered to multiple end users at lower cost and higher performance
- **Internet exchange points (IXPs):** locations where multiple networks can interconnect and exchange traffic within their country, including accessing content from Facebook caches.

These network elements allow content to be stored closer to the end user, which generally reduces transit costs to the ISPs. In order to receive content available on Facebook's platform, an ISP needs to establish a connection to Facebook's internal network. This can be achieved by the ISP peering with Facebook at an out-of-region PoP (which would require the ISP to pay for international links) or at a local or regional PoP (which can be located at an IXP; the ISP then only pays for connectivity to the PoP).

Additionally, an ISP can have a Facebook cache installed within its network.[18] Although this requires the ISP to pay for the traffic to fill the cache, it also yields significant savings for the ISP, because once the content is in the cache the ISP does not have to pay for the traffic when other users try to access the same content – it can be served from the cache, becoming even more efficient at particular times when international links are heavily utilised.

[17] Static content is akin to pre-recorded content, as once created it does not change and can be accessed many times over in the same exact form. In contrast, dynamic content is created and consumed at the same time; it can include voice and video communications, live video streams, and online gaming data, for example.

[18] Note that a Facebook cache can also be installed at a peering facility such as the IXP, where ISPs can access it (particularly small ISPs, for which it may not be feasible to install a Facebook cache within their own networks). In this case, IXP members can split the cost of filling the cache.

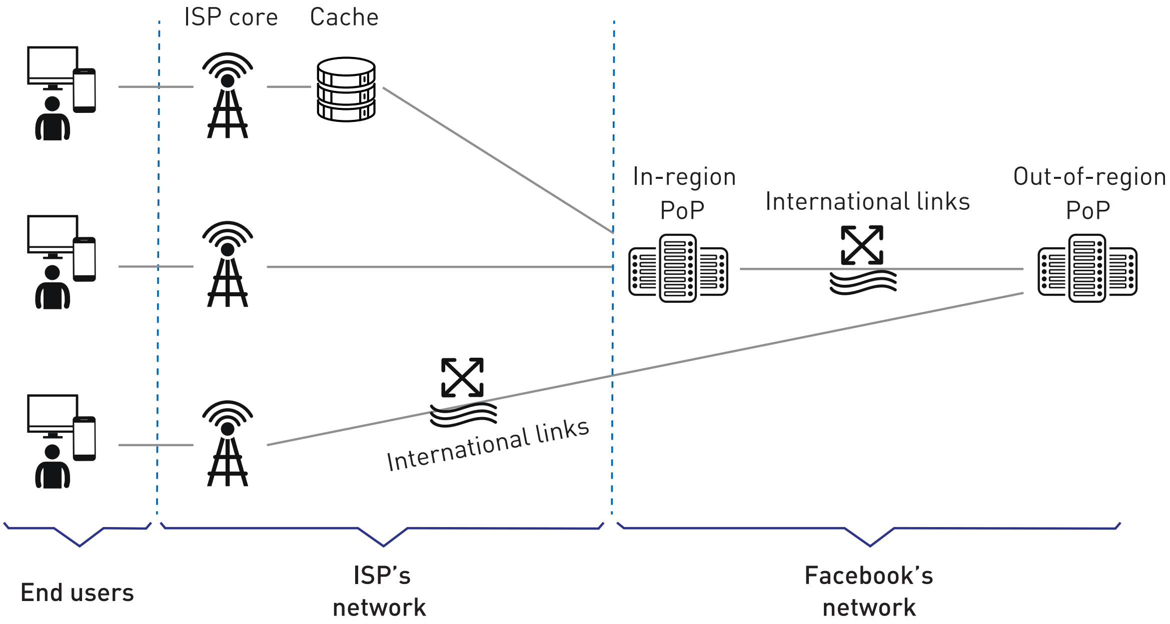
Interconnection: transit and peering

When end users request access to a piece of content or a service online, their request and the response often pass through multiple separate networks. These networks must be able to communicate with one another, either directly or indirectly through other networks. That is, the networks of ISPs, platforms providing content such as Facebook, research and educational organisations and enterprises are ***interconnected.***

The exchange of traffic between these interconnected networks relies on commercial agreements that fall broadly into two categories: ***transit*** provides access to all Internet destinations for a fee, while ***peering*** only provides reciprocal access between two networks. Generally, interconnection is established either through a bilateral agreement to exchange traffic at a dedicated PoP, or through a multilateral arrangement where multiple networks connect into an IXP. Facebook PoPs and caches may be collocated with IXPs, where multiple networks can interconnect and exchange traffic within their country, as well as accessing Facebook content on Facebook's platform.

Figure 3.5 provides a very simplified view of how traffic flows between end users and the Facebook internal network, through either international links, links to Facebook's PoPs in the region, or Facebook's caches in ISP networks.

FIGURE 3.5: SIMPLIFIED VIEW OF FACEBOOK INTERNAL NETWORK TOPOLOGY [SOURCE: ANALYSYS MASON, FACEBOOK, 2020]



PoPs

To date, Facebook has invested significant amounts to deploy three PoPs in sub-Saharan Africa, located in Johannesburg (South Africa), Mombasa (Kenya) and Lagos (Nigeria). ISPs and network operators can interconnect with the Facebook internal network at these locations, through an open peering policy, to access content and applications available on Facebook's platform.

Facebook's PoPs enable the exchange of all types of traffic, including dynamic content such as a users' instant messages and video calls. Facebook's investments in international capacity support its ability to transport the content from its major data centres to its PoPs within sub-Saharan Africa, where it exchanges traffic with the local networks. This allows parties that interconnect with Facebook at its PoPs to reduce their international connectivity and transit costs, because they no longer have to pay to bring the content into the region.

As well as making it more economical for ISPs to serve Facebook traffic, the PoPs give Facebook greater control over its internal network, thus improving the performance, reliability and resilience of its service delivery.

Caches

Cache servers are intelligent storage appliances (a type of computer server) which are deployed close to end users and replicate static content (e.g. photos, videos, thumbnails, text, ads) that would otherwise be stored in large data centres. They store content that is requested by end users for a period of time, so that it can be served efficiently to other users at a later stage.

This lowers the use of (or optimises) international capacity, cuts costs and improves user experience by reducing latency. In general, the network which hosts the cache pays for the connectivity needed to fill the cache,[19] although in effect this cost is recouped multiple times as a result of the cache being in place.

Facebook's caches are installed in ISP's networks across the world, including in 44 countries in sub-Saharan Africa. Caches may be hosted within the networks of large ISPs or may be in neutral locations, such as IXPs, where the cache can be reached by multiple network operators and ISPs.

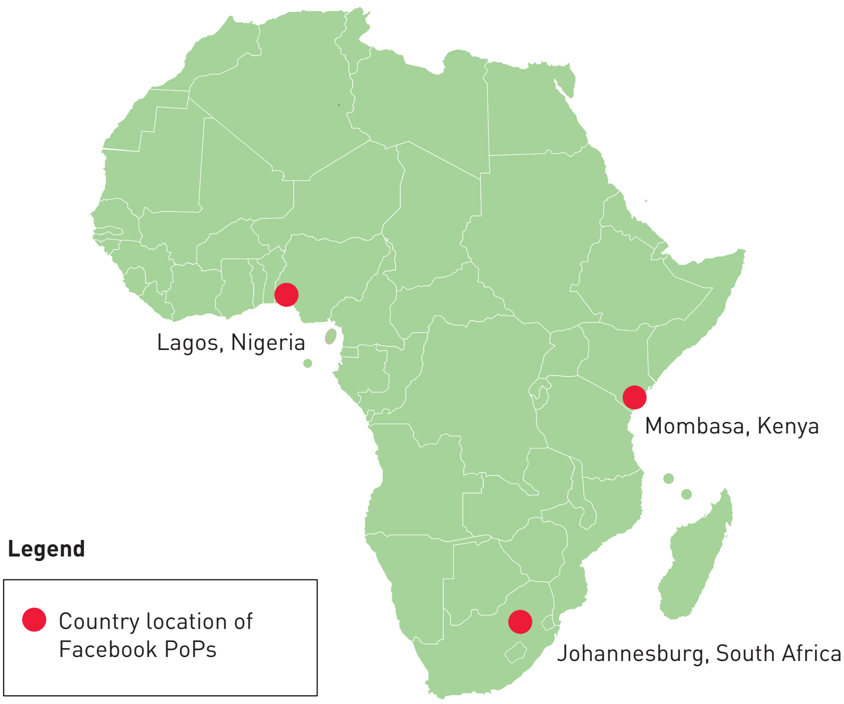
IXPs

IXPs enable operators to exchange traffic with one another and access content from a common Facebook cache. This can eliminate infrastructure duplication, as well as the need to use international transit to exchange traffic in other countries, thus reducing the costs and latency involved in delivering content requested by end users. IXPs tend to be non-profit associations, whose members can interconnect using shared facilities at cost-based rates.

Facebook would typically seek to deploy PoPs and caches within IXPs; in sub-Saharan Africa, Facebook is a member of IXPs in nine countries: Burundi, DRC, Gabon, Gambia, Kenya, Mozambique, Nigeria, South Africa and Uganda. Additionally, Facebook has partnered with the Internet Society (ISOC) to support IXP infrastructure development across Africa through workshops, training and community engagement. Since 2018, Facebook and ISOC have held 15 workshops and roadshows on best practices in interconnection, challenges in IXP development and regulatory considerations. At the time of writing, Facebook and ISOC were also planning to select five African IXPs, which will receive financial support to fill caches connected to the IXPs (not just Facebook caches), by covering the cost of transit capacity for up to three years.

[19] In the case where the operator is also connected to a Facebook PoP, it only pays to extend its network from the cache to the PoP, without paying for transit of Facebook's traffic from outside of the region

FIGURE 3.6: FACEBOOK POP LOCATIONS [SOURCE: FACEBOOK, ANALYSYS MASON, 2020]



Case study: The Burkina Faso IXP

The Burkina Faso IXP (BFIX) was established as an association of ISPs, mobile network operators (MNOs) and public institutions in February 2015 and was officially launched in July 2018. Following the launch and operationalisation of the exchange, a number of challenges remained, particularly in relation to network design optimisation. This prompted BFIX representatives to request technical assistance, and in January 2019, ISOC and Facebook conducted a one-week training programme for 18 stakeholder organisations, including sessions for managers and decision-makers and a technical workshop for network engineers.

Several weeks after the training, BFIX was able to improve its technical design and increase the efficiency of traffic routing. This removed network bottlenecks and allowed peak aggregate traffic to increase from 0.5Gbit/s to 6Gbit/s, with most of the traffic accounted for by edge caches accessible through the exchange. BFIX estimated that network operators have realised combined monthly cost savings of USD120 000, based on international transit costs.[20]

3.3 Backhaul fibre investments through Open Transport Network (OTNx) are accelerating the expansion of mobile broadband networks to more people

The Open Transport Networks (OTNx) initiative relates to Facebook's investments in fibre infrastructure for the purpose of establishing backhaul in developing countries. These projects are carried out in partnership with local operators, who deploy and maintain fibre-optic cable and equipment providing high-capacity backhaul connections to core networks. These connections enable mobile access networks to be upgraded to higher-speed (3G and 4G) capabilities and improve performance of existing technology or allow new network technologies such as Wi-Fi to be deployed.

The primary aim of OTNx projects is to enable operators

[20] Note that current Express Wi-Fi technology requires SMS verification on the customer side, so the presence of at least 2G connectivity is required in deployment areas.

to significantly improve the performance of mobile Internet services through introducing 3G/4G mobile broadband, in areas where only 2G was available, rather than to connect completely unserved areas.[21] Within sub-Saharan Africa, Facebook has already implemented the following OTNx projects, in partnership with local operators:

- **Uganda:** 770km of fibre deployed in partnership with operators BCS and Airtel.[22]
- **Nigeria:** between 750km and 800km of fibre deployed in partnership with infrastructure provider MainOne in economically unattractive parts of the Edo and Ogun states; additionally, some fibre links were built in metro areas of the state capitals.[23]
- **South Africa:** Facebook co-invested in 100km of fibre backhaul for Wi-Fi access points in the townships of Diepsloot and Katlehong.[24]

The two live OTNx deployments in Uganda and Nigeria have enabled a significant extension of 3G/4G coverage in the regions they serve, to over 4 million people (3 million in Uganda and 1 million in Nigeria).[25] This represents a significant share of the total fibre deployment reported for sub-Saharan Africa in 2018, which saw 28 million people across the region brought within a 25km range of the nearest operational fibre-optic network node (including 3 million in Uganda and 3.2 million in Nigeria).[26] However, as of June 2019, 45% of the sub-Saharan Africa population still lived more than 25km from a fibre network node.

Facebook's model for OTNx has been to co-fund deployments, with local operator partners having ownership of the infrastructure deployed. The resulting infrastructure operates on an open-access basis,[27] which means that the delivery of Facebook's traffic is not prioritised over delivery of other content. When selecting particular geographies for investment, Facebook prioritises large countries with a lack of fibre infrastructure, although it also needs to consider other factors such as the regulatory environment and interest from potential partners.

Case study: Uganda backhaul

In 2017, Facebook estimated that 18 million people in Uganda lacked access to a fast and reliable Internet connection. In an attempt to tackle this, Facebook brought together network operators Airtel and BCS to co-deploy fibre links to mobile towers, with the aim of ensuring sufficient backhaul capacity to enable the mobile networks to be upgraded to 3G/4G speeds. Facebook co-funded the deployment and used its network design expertise to advise the MNOs on technical specifications and deployment approach. Facebook initially owned 49% of the network, but after the deployment was completed it released this stake to the two MNOs, with a 50:50 ownership split.

The project resulted in the deployment of 770km of fibre in north-west Uganda, which improved high-speed network coverage in the area by 40%, and Airtel stated that the initiative was crucial for providing all of its towers with 3G capabilities. The deployment is estimated to have provided fibre backhaul connectivity to over 3 million Ugandans and can potentially support cross-border connectivity to neighbouring countries (South Sudan and DRC).[28]

[21] The remote and rural nature of most unserved communities would present financial, technical and demand-side challenges for fibre deployment.

[22] Facebook – "Airtel and BCS, with support from Facebook, to build shared fiber backhaul connectivity in Uganda", 27 February 2017

[23] MainOne press release (see https://www.mainone.net/mainone-and-facebook-announce-open-access-fiber-network-in-nigeria/)

[24] https://connectivity.fb.com/network-investments/

Note: This smaller-scale deployment took place in 2017, in partnership with wireless broadband operator Vast Networks (which went into liquidation in October 2019).

[25] Sources: BCS press release (see https://bcs-ea.com/facebook/); MainOne press release (see https://www.mainone.net/mainone-and-facebook-announce-open-access-fiber-network-in-nigeria/), Submarine Networks – "MainOne and Facebook Partner on Open Access Fiber Infrastructure in Nigeria", July 2019.

[26] See http://www.africabandwidthmaps.com/?p=6158; 25km is a sensible estimate of the feasible distance for providing wireless broadband coverage from a fibre node. A different distance could be chosen (depending on the bandwidth/QoS requirements), but 25km provides a reasonable threshold. As a point of comparison, 3G cellular sites typically have a site radius of around 10km in rural areas.

[27] Open access means that all operators may acquire wholesale access to the infrastructure on an equal basis.

[28] BCS press release, see https://bcs-ea.com/facebook/

4 Facebook's initiatives that support investments by operators

Operator facilitation initiatives are projects where Facebook provides advice, organisational support, software, or hardware to enable operator partners (MNOs and ISPs) to deploy and operate networks. Facebook does not own any part of the infrastructure deployed in relation to these initiatives; the goal is to support its partners in extending and upgrading their networks in a sustainable manner.

This section describes various operator facilitation initiatives being undertaken by Facebook, outlining the aim, functionality and business model of each initiative, and highlighting examples from sub-Saharan Africa. We first discuss Express Wi-Fi (Section 4.1), a solution developed by Facebook that combines low-cost Wi-Fi equipment with custom software and analytics capabilities to enable Internet connectivity at a much lower cost than traditional mobile cells. We then discuss initiatives under the 'Rural Access' umbrella (Section 4.2), which focus on solutions to drastically reduce rural connectivity costs and extend coverage to more communities. Finally, we outline a number of other operator facilitation initiatives (Section 4.3).

4.1 Express Wi-Fi brings cheaper data to new and existing Internet users

Express Wi-Fi is a software platform that Facebook offers free of charge to its partners – MNOs and ISPs – to enable them to deploy, operate and monetise Wi-Fi services. The software platform can be integrated into the partners' systems and includes a set of online tools for network monitoring and management. The platform also provides a choice of models for revenue generation through a browser app on users' devices: they can either purchase a data pack or adopt the freemium model (the latter requiring users to watch an advertisement instead of making a payment). These features enable operator partners to provide the service in a more efficient and affordable way, allowing them to extend service coverage into areas where there may have previously been no commercial case for network deployment.

Express Wi-Fi can be used to address a range of connectivity gaps:

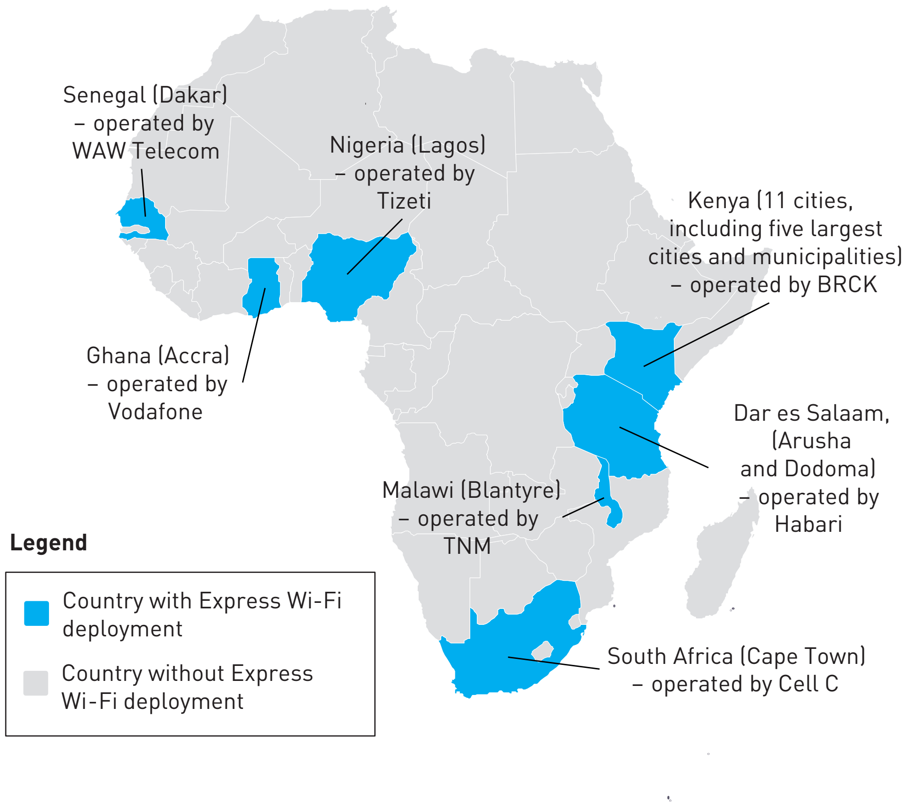
- **Coverage gap –** extending connectivity to areas previously underserved by (primarily mobile) broadband networks[29]
- **Usage gap –** boosting service usage by capturing new users within already covered areas and increasing their data consumption due to improved service quality and affordability
- **Capacity gap –** solving the problem of network overload in urban and semi-urban areas by allowing operators to offload their mobile traffic onto the Wi-Fi network.

In addition to the software, in some cases Facebook provides its operator partners with funding support for deployment of the Wi-Fi network. There are currently 17 countries worldwide with Express Wi-Fi deployments with over 30 live partners. Seven of these countries are in sub-Saharan Africa (see Figure 4.1).

A notable feature of the Express Wi-Fi operating model is that the sale of data packs to end users in communities is done via local entrepreneurs who have Express Wi-Fi hotspots installed in their shops. This creates a revenue stream for the entrepreneurs who act as resellers, providing a cash influx for local communities while reducing operational spend for operators.

[29] Note that current Express Wi-Fi technology requires SMS verification on the customer side, so the presence of at least 2G connectivity is required in deployment areas.

FIGURE 4.1: EXPRESS WI-FI DEPLOYMENTS IN SUB-SAHARAN AFRICA [SOURCE: FACEBOOK, ANALYSYS MASON, 2020]

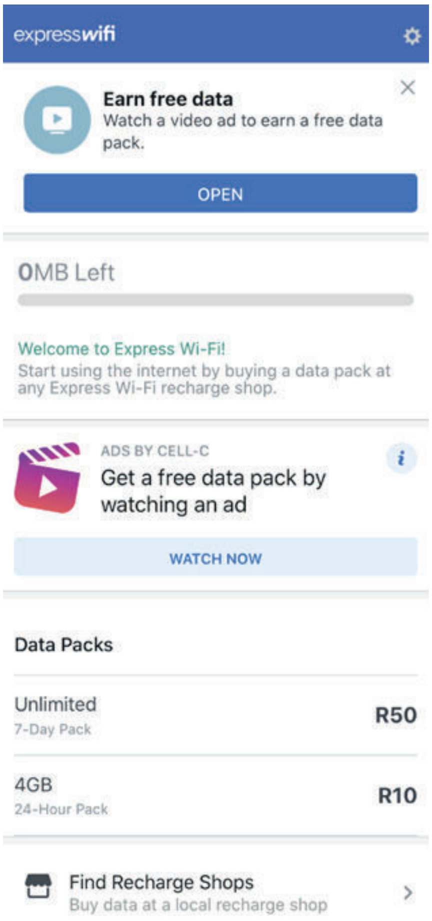


Case study: Express Wi-Fi in South Africa

Cell C, the third MNO in South Africa, partnered with Facebook to deploy Wi-Fi connectivity across various parts of the country, starting with the University of the Western Cape in early 2019. Since then, Cell C has established over 1200 Express Wi-Fi access points in municipal buildings, public areas and universities in Cape Town, Johannesburg and Bloemfontein. Cell C's eventual aim is to connect between 2 and 3 million people to the service.

Express Wi-Fi has allowed Cell C to reach additional users and increase its advertising revenue. Because of the high speeds enabled by the Wi-Fi technology and its independence from individual MNO cellular networks, the Wi-Fi service is able to target all mobile users, not just Cell C subscribers. Cell C can also use the user data that is generated by the service to improve user experience and marketing strategy, as well as potentially to co-operate with the government on development and delivery of e-government and smart-city services.

FIGURE 4.2: CELL C EXPRESS WI-FI MOBILE INTERFACE [SOURCE: FACEBOOK, CELL C, 2020]



4.2 Rural Access focuses on reducing the costs of rolling out broadband in less populated and poorer rural areas

The Rural Access programme encapsulates a variety of Facebook's initiatives designed to support the deployment of high-speed broadband infrastructure in rural areas by providing a combination of financial aid, network planning and technical advice, organisational and operational tools, and support in regulatory discussions.

The scope and shape of Facebook's Rural Access initiatives vary widely, reflecting the need to find innovative, tailored solutions to specific technological, geographical and socio-economic challenges. Facebook's largest Rural Access project is being deployed in Peru, where Facebook works alongside several MNOs and government bodies to extend 3G and 4G connectivity to rural areas of the country. Facebook helps its partners to identify and use efficient network planning tools and low-cost technological solutions enabling them to deploy mobile sites, to form an open-access wholesale network in the case of Peru.

Facebook's Rural Access team works to identify deployment opportunities based on the number and location of unconnected and 'under-connected' people, but projects also rely on the interest of an MNO partner. Within sub-Saharan Africa, Facebook has two primary Rural Access partnerships, as described further in the case studies below:

- A partnership with Africa Mobile Networks (AMN) in Cameroon and DRC to support the deployment of mobile sites in ultra-rural areas where no network coverage was previously available.
- A partnership with BRCK in Kenya and Rwanda to support the development and expansion of free Wi-Fi services that can address the affordability barrier, bringing new Internet users online and enabling more meaningful usage by existing Internet users.

Case study: AMN partnership in DRC

AMN's business model is to deploy cost-effective solar-powered sites in ultra-rural villages that have no access to grid power or backhaul infrastructure. MNOs are able to lease access to AMN's sites, which allows them to extend their network coverage and attract new subscribers, thus generating incremental revenue without incurring capital expenditure themselves.

Facebook has previously provided financial support to AMN, helping it to deploy mobile coverage to over 3 million people across 7 countries, with around 600 000 using the services. The majority of AMN's current sites are 2G, but Facebook is now providing investment to support AMN's trials to upgrade sites to 3G/4G in DRC in partnership with Orange. Following these trials, AMN hopes to be able to upgrade the majority of its sites to 3G/4G.

In addition to financial support, Facebook is advising AMN on technical matters, sharing data on usage and rural population density to support planning, and helping AMN to establish a functional and sustainable business model.

FIGURE 4.3: AMN 12-METRE TOWER
[SOURCE: AMN, 2019]

Case study: BRCK partnership in Kenya and Rwanda

BRCK is a Kenya-based provider which offers a free public Wi-Fi service, known as Moja. BRCK uses its own hardware devices, the latest iteration of which is called SupaBRCK (a rugged outdoor micro-server, which can be solar-powered), to receive, store and transmit cached content, which makes it cheaper and faster to serve content to end users. The service is monetised by requiring users to watch an advertisement or take part in a survey to earn points which can be redeemed for free time online.

Facebook has provided financial and technical support to BRCK's deployment of the Moja Wi Fi service on buses in Kenya and Rwanda. The majority of access points deployed to date (between 60% and 70%) are on Kenya's matatu buses – informally operated, privately owned fleets of minibuses – while the remainder of the roll-out is accounted for by Rwanda's government-run transit vehicles, making a combined total of around 2700 access points.[30] By providing free services, the transportation Wi-Fi project is helping to increase Internet usage among people who could not previously afford meaningful levels of connectivity.

Although the Moja deployment targets customers on the move rather than those exclusively in rural areas (10% of the matatu buses covered by the service serve Nairobi), this project falls under the Rural Access umbrella. Facebook's support for BRCK has taken the form of grants and loans, with further assistance provided to help BRCK commercialise the service and make sure the business model is sustainable. The partners are now considering expansion into other African markets.

FIGURE 4.4: BRCK'S SUPABRCK DEVICE
[SOURCE: BRCK, 2019]

[30] BRCK – "Moja + LTE: Extending affordable access further", 25 February 2019.

Another project in which BRCK is supported by Facebook is the trial deployment of a 4G (LTE) network to provide backhaul to access points and support efficient scaling of the Moja network. This involves deploying low-cost, solar-powered LTE towers, with BRCK using and contributing to Facebook's open-source Magma software platform to manage traffic and provide automated core network functionality. The Magma solution offers advantages over traditional core network design, as it allows caching of content at the LTE sites, which improves network performance and reliability and reduces data transport costs. The trial currently includes ten LTE sites, with potential for further expansion.

4.3 Facebook is spearheading other initiatives to reduce network and data costs

In addition to the initiatives described above, Facebook is working to identify new opportunities and develop new tools to support the provision of connectivity worldwide. As outlined below, it has a number of further initiatives at varying stages of development.

The Telecom Infra Project (TIP) is a collaboration platform, conceived by Facebook alongside four other founding members, which aims to facilitate discussion and cooperation among telecoms operators, vendors, governments and other stakeholders in order to design, build and deploy new and more cost-effective technological solutions and hardware. Having brought together over 500 global organisations under TIP, Facebook is facilitating collaboration among members via establishing project groups, carrying out knowledge sharing meetings and summits, and providing space and tools for joint work.

TIP helps to bring more players into the market at every step of the value chain, supporting start-ups and disrupting traditional vendor models. This plays a particularly important role in developing regions, such as sub-Saharan Africa, where competition and innovation are key to ensuring affordability. For instance, the Rural Access projects described above depend on technologies developed and improved within TIP.

Case study: OpenCellular deployment in Cameroon

Originally a separate initiative, OpenCellular has been brought under the TIP umbrella as one of its radio access network (RAN) projects[31] OpenCellular is a publicly available RAN hardware solution for 2G rural connectivity. Although Facebook has been shifting its focus towards a software-defined OpenRAN solution, OpenCellular hardware has been trialled in Cameroon.

In February 2018, the remote village of Akoualoui in Cameroon obtained 2G services for the first time through an OpenCellular deployment located at a nearby primary school. The solution enables lower-cost coverage and greater ease of deployment for operators due to power and backhaul optimisation, as well as low-maintenance site design. The Cameroon initiative covered 1000 rural inhabitants who previously had no connectivity.[32]

FIGURE 4.5: OPENCELLULAR BASE STATION
[SOURCE: FACEBOOK, 2019]

[31] A RAN is a wireless access network that provides connections to end users.
[32] See https://connectivity.fb.com/opencellular/

Another example of Facebook's connectivity initiatives under development is Terragraph, a solution to provide high-capacity wireless backhaul and fixed-wireless access (FWA) using high-frequency spectrum. The Terragraph solution is at the trial stage and has not yet been implemented in sub-Saharan Africa; however, data collected through an initial commercial deployment in Malaysia indicated a positive impact on Internet service take-up and speeds, at a lower cost to Facebook's MNO partner than alternative solutions.

While we have discussed a selection of Facebook's most advanced connectivity initiatives, there are many more at various stages of development. Facebook's connectivity teams continually work to identify and develop new initiatives that can be used to extend broadband coverage and make services more affordable. By addressing the barriers to connectivity and helping more people to achieve meaningful Internet access, these initiatives can deliver substantial economic and social benefits to the sub-Saharan African region, which we explore further in Section 5 below.

5 Economic impact of Facebook connectivity initiatives

Although Facebook's connectivity initiatives are diverse, they all share the same goals: reducing the barriers to connectivity and making the Internet more widely available, accessible and affordable to more people. Facebook's investments support the delivery of content available on its platform and improve engagement with Facebook applications, but they also create wider benefits to sub-Saharan Africa, by improving connectivity and access to online content and services more broadly. The resulting increase in take-up and usage of Internet access has wide-reaching benefits for economies in the region.

In addition to its direct investments in infrastructure in the region, Facebook has dedicated efforts and resources globally to develop the connectivity initiatives that are now being deployed in sub-Saharan Africa. We have quantified the impact of Facebook's connectivity initiatives by focusing on the improvement in connectivity outcomes that they enable, in terms of increased Internet traffic and take-up wof online services. Quantitatively, we estimate the economic impact of Facebook's initiatives to be **over USD57 billion in additional GDP over a five-year period between 2020 and 2024.**

This section explains how Facebook's initiatives translate into economic benefits, largely thanks to the increased connectivity and Internet use that they enable. Section 5.1 describes the economic impact derived from bringing new Internet users online for the first time (which is quantified for the OTNx backhaul investments), and from increasing Internet engagement and traffic (based on assessment of Facebook's investments in edge network infrastructure, submarine cable capacity and Express Wi-Fi). Section 5.2 then describes how economic value is created as a result of Facebook's direct investments, including through indirect and induced effects. Finally, Section 5.3 illustrates the effects of connectivity improvements on stakeholders (individuals, enterprises, governments) that result in the overall social and economic gains.

5.1 Increased connectivity outcomes enabled by Facebook's initiatives, in the form of new users and additional traffic, create significant economic value

Facebook's initiatives enhance operators' ability to extend the coverage of broadband networks, thus enabling more people to go online (a higher *take-up*[33] of Internet access services). They also stimulate more meaningful use of the Internet by improving the quality of access networks (e.g. higher speeds) and the performance of service delivery (e.g. through lower latency), which results in higher Internet *traffic*.[34]

The initiatives also reduce the costs faced by operators and ISPs in providing connectivity and content to end users, enabling them to provide more-affordable services. The resulting improvements in connectivity and Internet usage can then translate into economic and social benefits, as illustrated in Figure 5.2 and Figure 5.3 below.

[33] *Take-up* reflects the number of people who use Internet services, often expressed as a share of national population ('penetration'); take-up increases when service coverage is extended and more people have the opportunity to get connected. Additionally, take-up within covered areas (i.e. the number of people who have access to the Internet and choose to use it) can be expected to increase when service quality and affordability improve, as the value of the service to the user goes up.

[34] *Traffic* refers to the amount of content and data consumed by the average Internet user. It is primarily a function of affordability and quality of connectivity and services, and improvements in these factors allow users to consume more content online.

FIGURE 5.1: FLOW FROM FACEBOOK CONNECTIVITY INITIATIVES TO ECONOMIC AND SOCIAL BENEFITS
[SOURCE: ANALYSYS MASON, 2020]

FIGURE 5.2: IMPACT OF FACEBOOK INITIATIVES ON CONNECTIVITY OUTCOMES [SOURCE: ANALYSYS MASON, 2020]

Initiative	Coverage	Quality	Affordability
Infrastructure investments			
Submarine cables	—	✓	✓
Edge network	—	✓	✓
OTNx	✓	✓	✓
Operator facilitation initiatives			
Express Wi-Fi	✓	✓	✓
Rural access	✓	—	✓
Other initiatives	✓	✓	✓

These increases in take-up and traffic mean that people are more able to obtain and disseminate information, interact with other people, enterprises and government agencies, and perform transactions online. All these activities create benefits for individual stakeholders as well as wider economic and social benefits through improved health and welfare outcomes, skills and education, job creation and productivity. We have sought to quantify these benefits in terms of the additional GDP that could stem from them over the next five years, which we estimate at over USD56 billion. This is shown in Figure 5.4 and explained further below.

FIGURE 5.3: ESTIMATED CUMULATIVE IMPACT OF FACEBOOK CONNECTIVITY INITIATIVES, 2020–2024
[SOURCE: ANALYSYS MASON, 2020; ALL VALUES IN NOMINAL USD AT PROJECTED CURRENT EXCHANGE RATES]

Source of impact	Drivers of impact	Cumulative 2020–24 GDP impact, USD billion 2015
OTNx	High-speed Internet take-up	3.9
Edge networks and submarine cables	Internet traffic / data usage	53.4
Express Wi-Fi	High-speed Internet take-up and Internet traffic / data usage	0.3
Total		**57.6**

Facebook initiatives support economic growth by increasing Internet take-up

In 2018 only 20% of people in sub-Saharan Africa had used the Internet, which is hampering the economic development of the region. A 2019 study by the ITU used econometric analysis of data from the majority of countries in Africa to determine that a 10% increase in mobile broadband penetration (e.g. from 20% to 22%) in Africa would yield a 2.5% increase in GDP per capita in a given year, over and above the baseline growth projected for the country or region.[35]

A key example of Facebook initiatives bringing new users online is its investments in fibre backhaul through the OTNx programme. As discussed in Section 3.3, these investments in Uganda and Nigeria have enabled coverage of high-speed broadband (3G/4G/Wi-Fi) to be extended to 4 million people. It can be expected that this coverage will enable high-speed Internet take-up in the affected region to scale up and reach the national average earlier and faster than would have happened without Facebook's investment, leading to an uplift in the national take-up level.

In estimating the impact we assume that take-up in areas where OTNx has been deployed will converge with the forecast national average by 2020 (three years after the infrastructure deployment in 2017), whereas without Facebook's investment high-speed Internet take-up in the region would not converge with the national average until 2025. This results in 0.7 million people in Uganda and 0.3 million in Nigeria getting online earlier than they would have done without the OTNx investments which enabled operators to extend their 3G and 4G coverage. Projections of take-up of high-speed Internet in areas of Uganda and Nigeria covered by OTNx are presented in Figure 5.5 and Figure 5.6, respectively.

FIGURE 5.4: HIGH-SPEED INTERNET TAKE-UP IN UGANDA OTNX DEPLOYMENT AREAS
[SOURCE: ANALYSYS MASON, GSMA INTELLIGENCE, 2020]

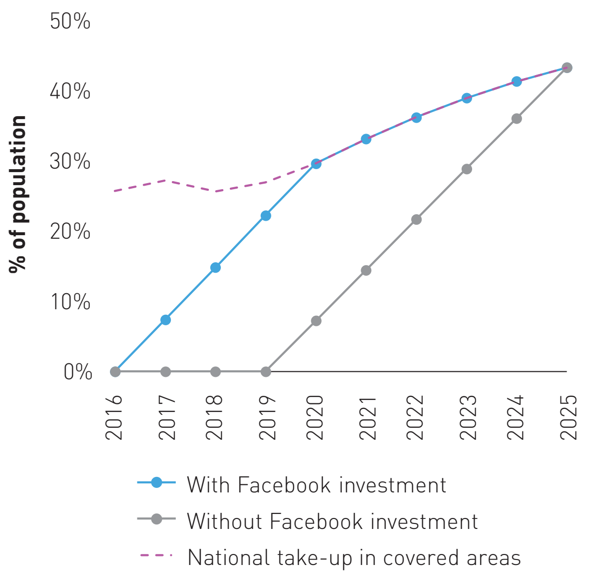
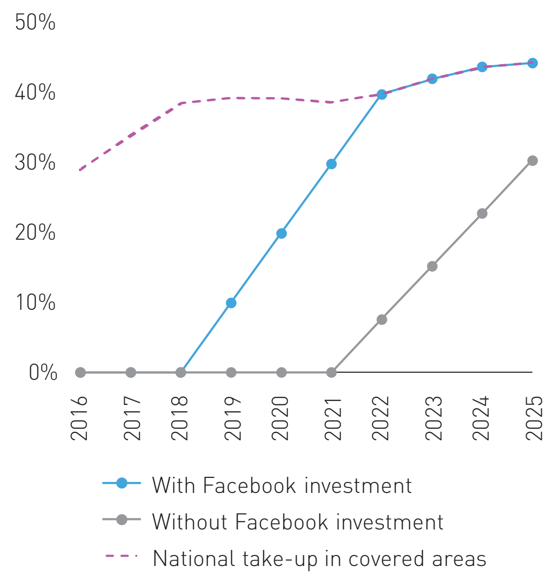


FIGURE 5.5: HIGH-SPEED INTERNET TAKE-UP IN NIGERIA OTNX DEPLOYMENT AREAS
[SOURCE: ANALYSYS MASON, GSMA INTELLIGENCE, 2020]

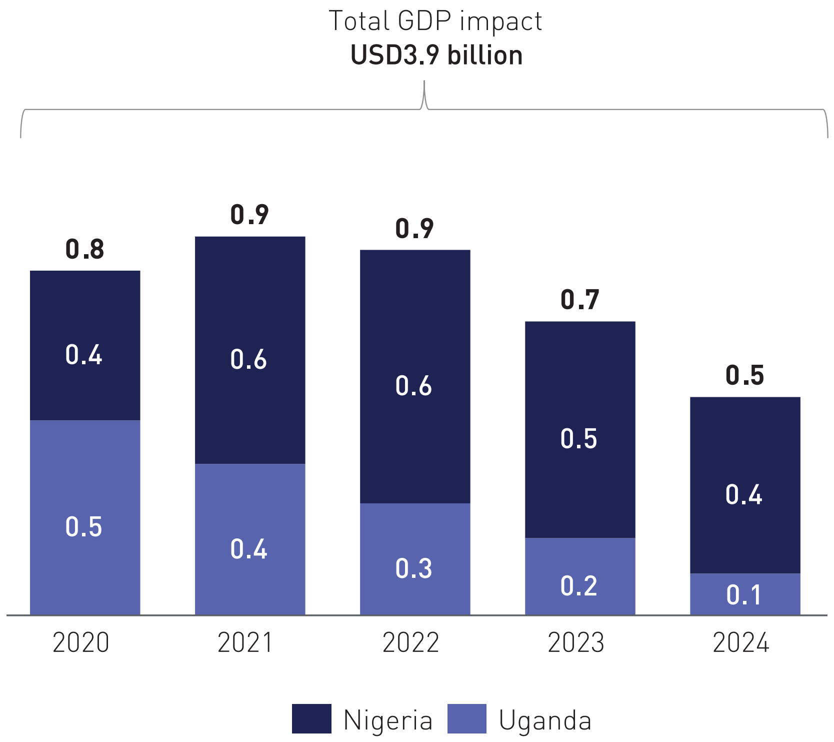


Based on the relationship between Internet take-up and GDP identified in the ITU study mentioned above, the increased take-up enabled by Facebook's OTNx investments could have a GDP impact of almost USD4 billion between 2020 and 2024, across Uganda and Nigeria (Figure 5.7).[36] This is a conservative estimate, because our calculation assumes that mobile broadband coverage and the resulting take-up would have been slower in the absence of Facebook's initiative, but that take-up will have caught up with the national average by 2025.

[35] Economic contribution of broadband, digitization and ICT regulation, ITU 2019. See: https://www.itu.int/dms_pub/itu-d/opb/pref/D-PREF-EF.BDT_AFR-2019-PDF-E.pdf

[36] We calculate the GDP impact from 2020 onwards, as the 2017–2019 effect will have been included in the historical GDP values for the two countries. However, there is still some impact, compared to the case with no Facebook investment, so our number is conservative. The detailed methodology used to derive this estimate is described in Annex A.

FIGURE 5.6: PROJECTED YEARLY GDP IMPACT OF FACEBOOK'S OTNX INITIATIVES IN SUB-SAHARAN AFRICA [SOURCE: ANALYSYS MASON, EUROMONITOR, 2020]



This economic impact relates only to the two countries where OTNx has already been deployed, enabling coverage to be extended earlier to a total of 4 million people. If the OTNx initiative were to be extended to the five countries in the region with the highest number of unconnected people (Ethiopia, DRC, Tanzania, Kenya and Sudan), the initiative's 3% population coverage within each could accelerate provision of coverage to a further 23 million people, which could generate an additional GDP impact of USD11.7 billion between 2020 and 2024.[37]

Facebook initiatives drive growth in Internet traffic, which in turn supports economic growth

In addition to helping new users get online, Facebook connectivity initiatives improve the quality and affordability of connectivity, which can lead to increased traffic and greater use of online services. This increased engagement with the Internet can translate into economic growth, as evidenced by a 2012 study by the GSMA and Deloitte.[38] This study found that, on average, if a country doubled its traffic consumption per mobile broadband user over a five-year period, this would lead to a 0.5% increase in GDP-per-capita growth rate in each of these years.

While all of Facebook's connectivity initiatives help to drive or facilitate increased Internet traffic to some degree, including to its own applications, we estimate that the most significant impact results from its investments in edge network infrastructure (caches, PoPs and support to IXPs) and international capacity on submarine cables.

[37] Assuming high-speed deployment start in 2020 with Facebook's involvement and in 2023 without it. Note: For the Nigeria and Uganda initiatives, population coverage of the OTNx initiatives was 0.5% and 7.0%, respectively.

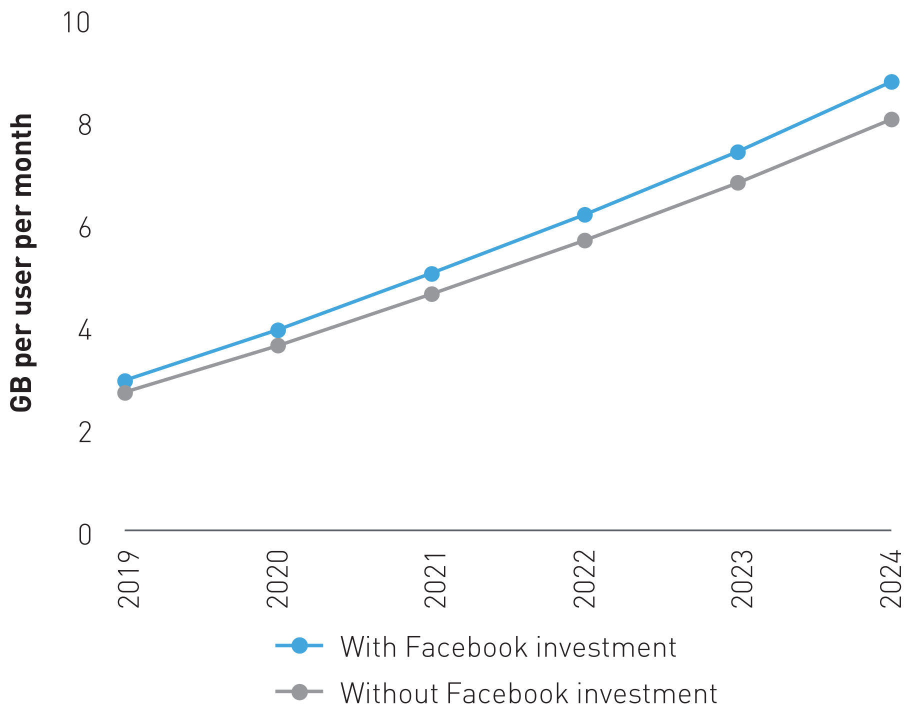
[38] GSMA, Deloitte – "What is the impact of mobile telephony on economic growth?", November 2012; See: https://www.gsma.com/publicpolicy/wp-content/uploads/2012/11/gsma-deloitte-impact-mobile-telephony-economic-growth.pdf; Note: we have not carried out a detailed review of the GSMA and Deloitte methodology; a purposeful triangulation of the take-up to GDP per capita growth and traffic to GDP per capita growth parameters, with a view of specific markets and timeframes, may alter the modelling results presented within this report.

As discussed in Section 3.2, these investments improve the performance of Facebook's applications and reduce latency. Furthermore, the popularity of Facebook's platforms means that operators and ISPs would likely still carry as much Facebook / Instagram / WhatsApp traffic as they could in the absence of Facebook's edge network investments, and so these investments free up budget and capacity on operators' and ISPs' networks to carry more traffic from other online service and content providers. Overall, Facebook's investments make data cheaper and more affordable for end users, which drives growth in overall Internet usage.

We estimate that across sub-Saharan Africa, Facebook's investments in edge network and international capacity will enable total Internet traffic to increase by 9% by 2024, relative to what could have been expected if this infrastructure was not in place (Figure 5.7).

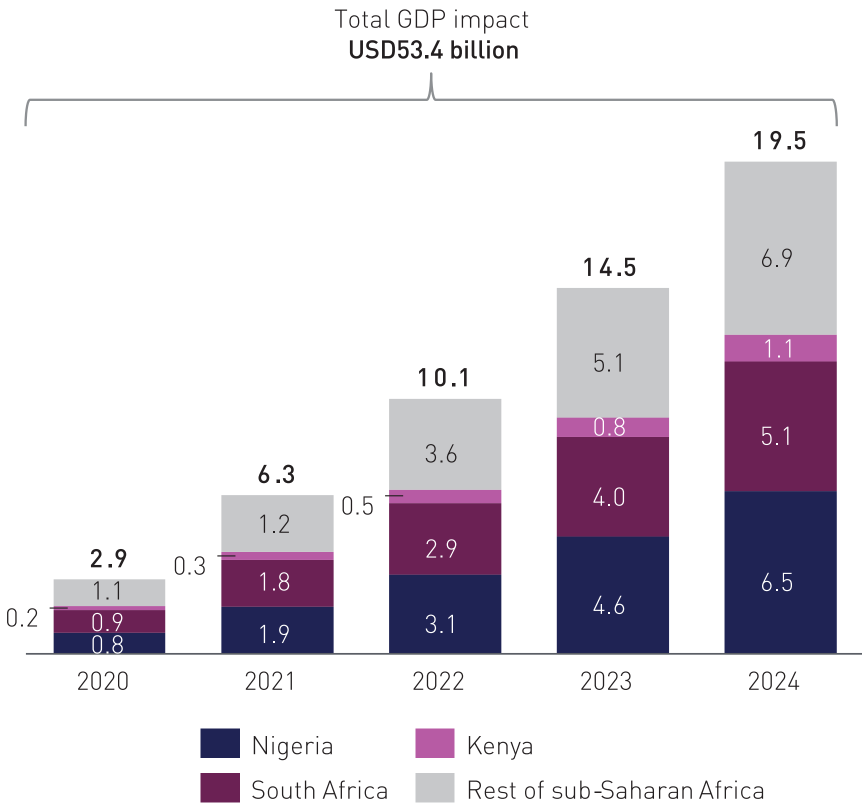
Based on the GSMA and Deloitte study, this higher traffic could increase the GDP-per-capita growth rate by 0.12 percentage points in each of the next five years, equivalent to a cumulative GDP contribution of more than USD53 billion across sub-Saharan Africa over the next five years (2020–2024, see Figure 5.8).[39] Nigeria, South Africa and Kenya would benefit the most, thanks to the presence of Facebook PoPs. The other countries in the region benefit from local caches used to store static content, as well as their proximity to the regional PoPs.

FIGURE 5.7: AVERAGE MONTHLY DATA USAGE PER USER IN SUB-SAHARAN AFRICA, [SOURCE: ANALYSYS MASON, 2020]



[39] The detailed methodology used to derive this estimate is described in Annex A.

FIGURE 5.8: PROJECTED YEARLY GDP IMPACT OF FACEBOOK'S EDGE NETWORK AND SUBMARINE CABLE INVESTMENTS IN SUB-SAHARAN AFRICA [SOURCE: ANALYSYS MASON, 2020]



Express Wi-Fi makes broadband services more affordable than existing 3G or 4G networks, which brings some new users to the Internet, and enables existing 3G/4G users to consume more data more cheaply. In one of the initiative's markets, Facebook's operator partner found that each Express Wi-Fi user was consuming almost 50% more data than an average 3G/4G broadband user in the country. If this uplift was extrapolated to Express Wi-Fi users across six countries in sub-Saharan Africa, it would imply an additional 48PB of traffic over the next five years. We estimate the combined effect of this additional traffic and users to be around USD323 million in cumulative GDP between 2020 and 2024 (Figure 5.9).

5.2 Facebook's initiatives create economic value both as a direct result of investment, and through multiplier effects

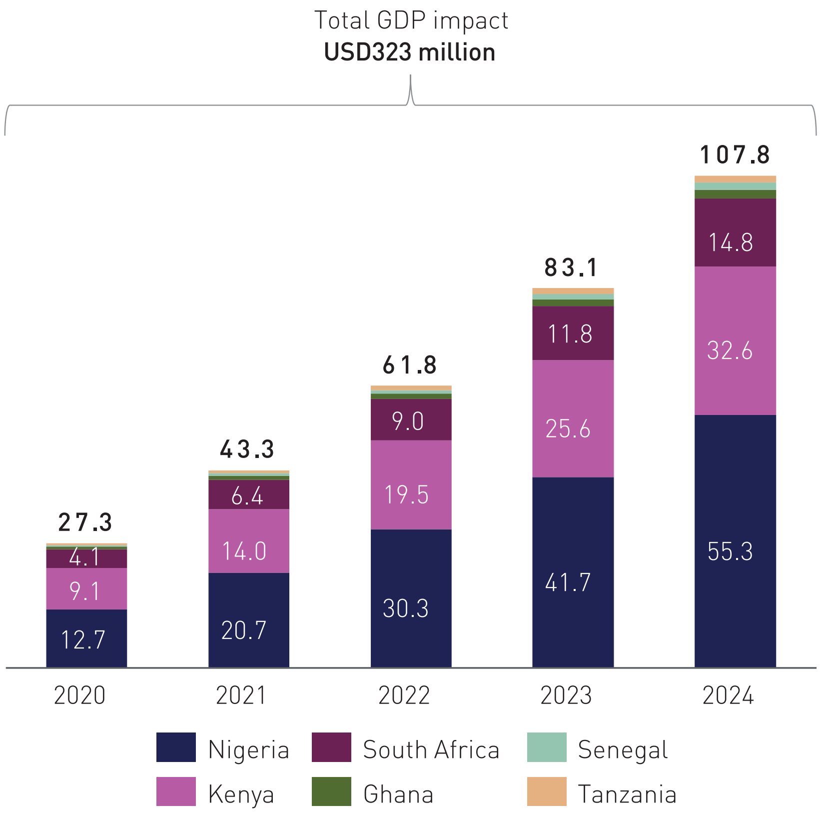
The most straightforward way in which Facebook's initiatives benefit economies in sub-Saharan Africa is through the economic activity involved in building infrastructure within the region. This creates local jobs and provides a boost to local economies.

A study by Copenhagen Economics found that infrastructure investment by Google in Europe not only creates direct benefits in terms of jobs required for construction, maintenance and project management, but also produces further positive economic outcomes through indirect and induced effects (i.e. effects in the broader supply chain and the knock-on impact on the broader economy of the jobs created and income generated). According to the study, network connectivity investments can have a GDP multiplier of 1.35, meaning that for every USD1 of direct investment a further USD1.35 of GDP is generated through indirect and induced effects.[40]

Facebook has made substantial investments in sub-Saharan Africa in recent years, including in its edge network, capacity on existing submarine cables and in its OTNx deployments. While much of the direct investment benefit is likely to accrue outside the

[40] While investments in sub-Saharan Africa are likely to exhibit a different multiplier effect to Europe, the general principles are the same for both regions

FIGURE 5.9: PROJECTED YEARLY GDP IMPACT OF FACEBOOK'S EXPRESS WI-FI INITIATIVES IN SUB-SAHARAN AFRICA [SOURCE: ANALYSYS MASON, 2020]



region, due to construction being carried out by international infrastructure operators and Facebook using its global team to manage the initiatives, the indirect and induced effects should take place within sub-Saharan Africa, generating additional GDP.

Most importantly, however, these investments support future growth in connectivity, the potential impact of which greatly exceeds the direct investment effects.

5.3 The economic and social gains from Facebook's connectivity initiatives stem from impacts on various stakeholders

The macroeconomic impact on GDP presented above stems from the increased availability of information, services and digital tools on various stakeholders (individuals, enterprises and governments). In this section we present tables providing a breakdown of the constituent impacts of connectivity on the economy and society, looking at these three groups of stakeholders in turn.

For example, individuals' access to health information and e-health services results in longer life expectancy and improved health outcomes, which has a positive impact on labour market participation and GDP. Below we highlight a selection of these many benefits, which are illustrated through sample metrics and examples. Note that these benefits are not additional to the GDP impacts estimated in Section 5.2, but rather they serve to illustrate how those impacts are accrued.

FIGURE 5.10: INDIVIDUALS BENEFIT THROUGH INCREASED ACCESS TO INFORMATION AND SERVICES, WHICH LEADS TO IMPROVED QUALITY OF LIFE, HEALTH, EDUCATION AND INCOME[41]

Impact metric	How connectivity affects outcomes	Examples of Internet-enabled service
Reduction in infant mortality	A 1 percentage point (pp) change in Internet take-up reduces infant mortality for the served communities by between 0.68pp and 1.43pp	• According to a 2017 survey by Pew Research Centre, 32% of sub-Saharan Africa Internet users use connectivity to obtain health information • mHealth services with nutritional information provision led overall nutrition knowledge levels to improve by an average of 12pp and nutrition behaviour to improve by an average of 13pp
Reduction in number of deaths	A 1% increase in Internet take-up should reduce deaths by 0.15% on an annual basis	
Increase in the number of people treated for HIV	A 1% increase in Internet take-up should result in an additional 1.26% of HIV-infected people receiving treatment	• Vodacom South Africa helped roll out iDart, a software solution for managing the stocks and dispensing HIV medication; between 2009 and 2014, the software was used to arrange 300 000 treatments for HIV patients
Improved learning outcomes	14% of Internet users take at least one online course per year	• Out of more than 260 students surveyed by the University of Nairobi in Kenya in 2018, 79% indicated that using the Internet helped them to access quality and up-to-date information, 49% indicated that the Internet made it quicker for them to receive and complete assignments, 41% indicated that the Internet had improved their communication with lecturers, and 70% indicated the Internet had helped them share information
Increased number of online job applications	26% of Internet users search or apply for a new job	• Jobberman, a Nigeria-based job portal founded in 2009, currently receives 1 new application every 35 seconds, and there are 1000 employment seekers trying to find a job at any given time. Within the last 2 years the platform has helped 35 000 people to find a job and it currently operates in more than 20 areas across Nigeria
Improved financial inclusion	A 1% increase in Internet take-up should increase the number of banked people by 0.42%	• By the end of 2017, Tala Mobile, a micro-credit company in Kenya, the Philippines, India and Mexico had sent over USD20 million in loans to 150 000 customers globally – and achieved a repayment rate of 90%

[41] Sources: Viswanath, V., Arun R. (2017), Sykes T. and Aljafari R.:'Combating infant mortality in rural India: evidence from a field study of eHealth kiosk implementations'. The impact range taken is between the 4th and the 7th year; Silver L. and Johnson C.: 'Internet connectivity seen as having positive impact on life in Sub-Saharan Africa'; Deloitte: Value of connectivity, economic and social benefits of expanding Internet access, 2014; Onyancha O. and Ngulube P.: Internet use among university students in Kenya: a case study of the University of Nairobi, 2018; https://www.jobberman.com/; Lenka S. and Barik R.: 'Has expansion of mobile phone and Internet use spurred financial inclusion in the SAARC countries?', 2018; Forbes, Adams S.: 'How Tala Mobile is Using phone to Revolutionise Microfinance'.

FIGURE 5.11: FOR ENTERPRISES, CONNECTIVITY BENEFITS RESULT FROM INCREASED ORGANISATIONAL EFFICIENCY AND EASE OF REACHING AND COMMUNICATING WITH CUSTOMERS[42]

Impact metric	How connectivity affects outcomes	Examples of Internet-enabled service
New businesses created	A 1% increase in residential connectivity penetration should lead to 0.47% growth in the number of firms	• Over the first part of 2019, 44 African start-ups raised over USD1 million – or a combined total of over USD450 million – across various industries. 34% of the start-ups operate in the fintech sector. 85% of the start-ups are headquartered in South Africa, Nigeria, or Kenya. • The number of tech hubs (organisations offering support and facilities for tech entrepreneurs) in Africa grew by 50% between 2018 and 2019, reaching 618 (compared to 442 in March 2018 and 314 in 2016)
Development of e-commerce	Products purchased online are estimated to be 10% cheaper than their offline counterparts	• Jumia (Nigeria) was founded as an online shopping mall and has since expanded into an ecosystem of online marketplaces. Jumia offers over 29 million products and had over 700 million visits to its marketplace in 2018. The company has secured total equity funding of USD211 million and is already celebrated as the first African 'unicorn' worth over USD1 billion
Development of the agriculture sector	Farming alone accounts for about 55% of employment across sub-Saharan Africa, and even more if dependent sectors are taken into account (such as agriculture products logistics)	• Farmcrowdy, an online platform in Nigeria that connects investors with local farmers, has already helped over 11 000 rural farmers to expand their operations. The platform has recorded over 35 000 transactions since 2016 • Supply chain online platform iProcure in Kenya links farmers with farmer cooperatives to increase the efficiency of product delivery, which in turn leads to a 10% to 20% price reduction on most farming products
Business performance improvement	Enterprises connected to the Internet have higher productivity (10% higher in the services sector, 20% in information and 5% in manufacturing)	• The Kopo-Kopo platform enables small and medium-sized enterprises (SMEs) to accept mobile payments and improve relationships with their customers through electronic payment products such as MasterPass QR in 11 markets in sub-Saharan Africa. Through this initiative, 250 000 African SMEs are expected to obtain an efficient and secure acceptance solution and a convenient consumer

[42] Sources: DIRSI: 'The Internet and Poverty: Opening the black box', July 2014; Internet Society: 'Promoting the African Internet Economy', 2017; American Economic Review - Are Online and Offline Prices Similar? Evidence from Large Multi-Channel Retailers, January 2017; Internet Society: 'Promoting the African Internet Economy', 2017; Malabo Montpellier Panel: 'Byte by Byte, policy innovation for transforming Africa's food system with digital technologies', 2019; World Bank; ITU: 'The impact of broadband on the economy', 2012; Kopo-Kopo website; GSMA Intelligence – '618 active tech hubs: The backbone of Africa's tech ecosystem', July 2019.

FIGURE 5.12: FOR GOVERNMENTS, CONNECTIVITY IMPROVEMENTS CAN ALSO BOOST EFFICIENCY AND TRANSPARENCY, AS WELL AS INCREASING THE REACH AND QUALITY OF E-GOVERNMENT SERVICES[43]

Impact metric	Research-based relationship between the metric and connectivity outcomes	Examples of Internet-enabled service
Information provision	Internet connectivity should significantly increase the availability of high-quality, timely and reliable data, which can spur innovation and create opportunities for all stakeholders	• In 2011, the Kenyan government introduced the 'Kenya Open Data Initiative' (KODI), allowing public access to key government data. This provided transparency, and within 4 years more than 50 mobile applications had been developed using the information available online. KODI now has more than 680 datasets, sourced from 31 different agencies. It has now introduced a 'request-a-dataset' feature on the portal, to help it to determine the needs of citizens and interested organisations
Policing corruption	Meaningful Internet connectivity provides a way to overcome the most significant barrier in identifying corruption – the need to ensure anonymity for the information provider	• In the past, corruption in Kenya could only be reported by email, telephone or fax, which provided no anonymity protection for information providers. In 2006, the Kenya Anti-Corruption Commission introduced the 'Business Keeper Monitoring System' to improve the quality and quantity of corruption reports. Three years later the share of reports resulting in discovery of instances of corruption increased from 21% to 37.8%
e-government service take-up	84% of people receive payments in cash. The ability to receive digital non-cash payments from government should significantly reduce risks of money transit	• The National Identification System implemented in Cape Verde between 2007 and 2009 that computerised electoral lists and enabled e-services such as online birth certificate registration and online business registration was found to have improved citizens' confidence in the electoral system: following the introduction of the programme, voter turnout for municipal elections on May 2008 reached 80%

[43] Sources: Kenya openData website; Guerriero M.: The impact of Internet connectivity on economic development in Sub-Saharan Africa, 2015; The World Bank - The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution; United Nations: E-government Survey, 2018; UNDP – From connectivity to service delivery: Case studies in e-governance, 2013.

Annex A Impact assessment methodology

This annex details the methodology used to estimate the impact of Facebook initiatives.

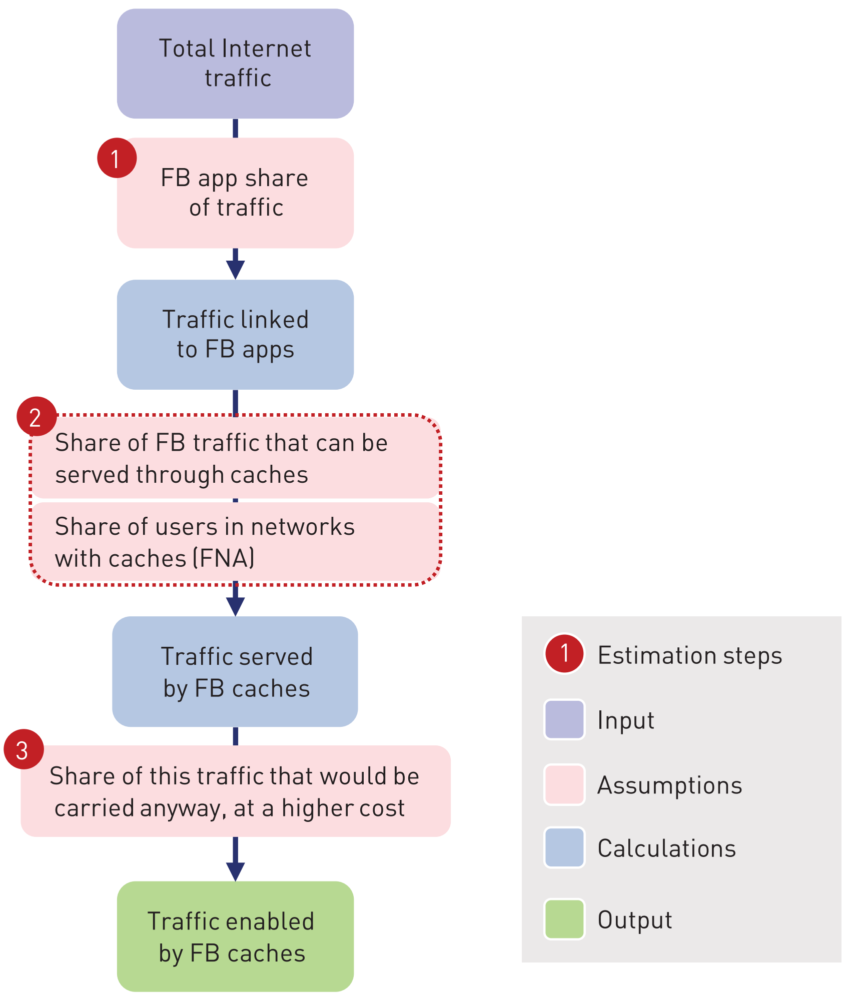
A.1 Edge networks and submarine cable investments

A.1.1 Estimating traffic enabled by Facebook caches

The following steps are taken to estimate the traffic enabled by Facebook (FB) caches (illustrated in Figure A.1 below).

- **Step 1:** Traffic linked to Facebook's applications (Facebook, Instagram, WhatsApp) is estimated as a share of total Internet traffic in the region.
- **Step 2:** Traffic served by Facebook caches is estimated by further adjusting Facebook's traffic by the following parameters:
  - share of Facebook traffic that can be served through caches; that is, the traffic that can be static (i.e. stored and requested on demand), unlike video calls and messaging content that needs to be dynamic
  - share of users in networks with caches; that is, the share of the region's Internet users who are served by ISPs that access Facebook caches.
- **Step 3:** Traffic enabled by Facebook caches is estimated by adjusting the traffic served by Facebook caches by a parameter reflecting the share of this traffic that would be carried anyway, by ISPs at a higher cost, if Facebook caches were not available.

FIGURE A.1: ESTIMATING THE TRAFFIC ENABLED BY FACEBOOK CACHES [SOURCE: ANALYSYS MASON, 2020]



A.1.2 Estimating traffic enabled by Facebook PoPs

The following steps are taken to estimate the traffic enabled by Facebook PoPs (illustrated in Figure A.2 below), starting from the traffic linked to Facebook applications (described above).

- **Step 1:** Traffic linked to Facebook's applications (Facebook, Instagram, WhatsApp) is estimated as a share of total Internet traffic in the region.

  Traffic served by Facebook PoPs is estimated by further adjusting Facebook's traffic by the following parameters:

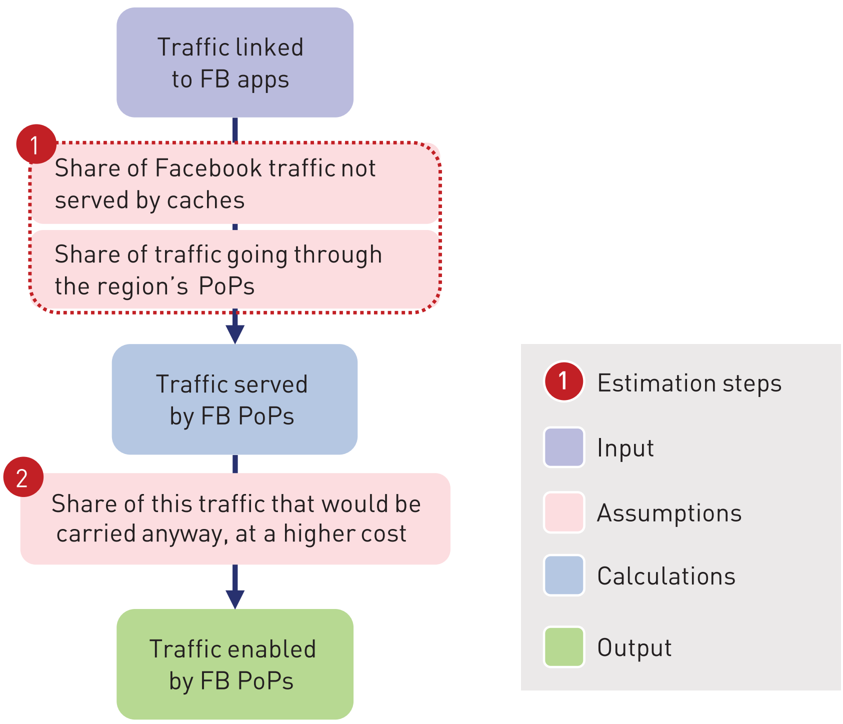
  - Share of Facebook traffic that is not served by caches
  - Share of Facebook traffic going through the region's PoPs. This share varies by country, depending on the extent of its connectivity to a PoP within and outside the region. An ISP can generally obtain Facebook traffic through one of four models:

1. IP transit from home country (generally very expensive)
2. Backhaul to regional hub + IP transit
3. Backhaul to regional hub with Facebook PoP + peering
4. Backhaul to rest-of-the-world (RoW) hub with Facebook PoP + peering

For a given country, the share of Facebook's traffic that goes through regional PoPs therefore depends on whether the country can easily obtain backhaul to a PoP (i.e. at reasonable cost and without regulatory hurdles that would prevent this) relative to the alternative of purchasing connectivity to other regions such as Europe.

- **Step 2:** Traffic enabled by Facebook PoPs is estimated by adjusting the traffic served by Facebook PoPs by a parameter reflecting the share of this traffic that would be carried anyway, by ISPs at a higher cost, if Facebook PoPs were not available.

FIGURE A.2: ESTIMATING TRAFFIC ENABLED BY FACEBOOK POPS [SOURCE: ANALYSYS MASON, 2020]



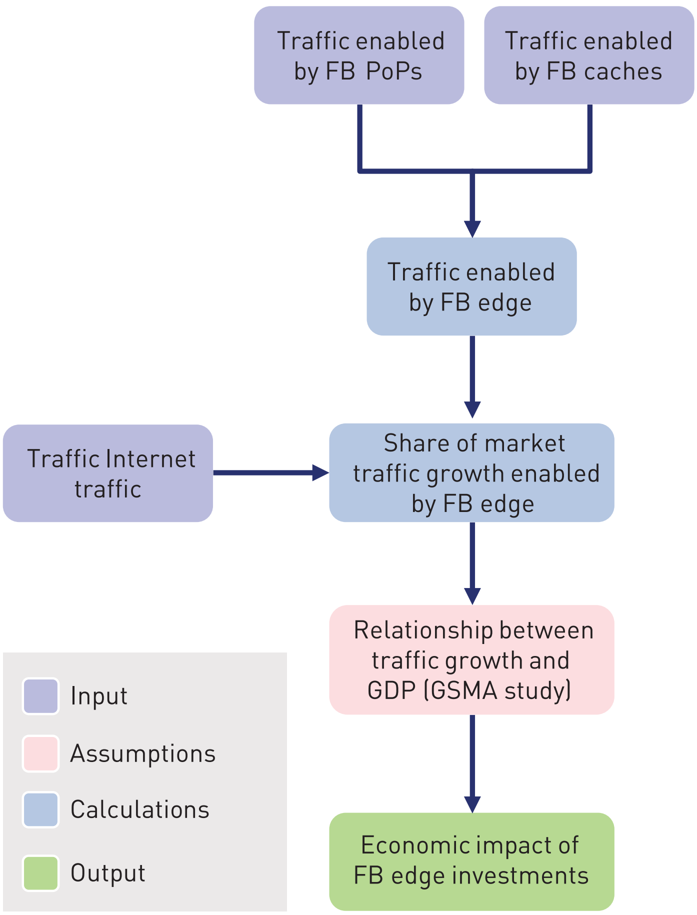
A.1.3 Estimating the GDP impact of Facebook caches and PoPs

The total traffic enabled by Facebook's edge investments is the sum of traffic enabled by its caches and traffic enabled by its PoPs. A comparison of this traffic to the total Internet traffic shows the growth in traffic volume that can be attributed to Facebook's edge investments, and by applying the link between traffic growth and GDP (put forward by GSMA and Deloitte – see below) it is possible to estimate the GDP enabled by these initiatives.

Relationship between traffic growth and GDP

The 2012 study by GSMA and Deloitte established that, on average, if a country doubled its traffic consumption per user over five years, it would experience a 0.5% increase in GDP per capita growth in each of these years.[44]

FIGURE A.3: CALCULATING THE ECONOMIC IMPACT OF FACEBOOK'S EDGE NETWORK INVESTMENTS
[SOURCE: ANALYSYS MASON, 2020]



[44] GSMA, Deloitte – "What is the impact of mobile telephony on economic growth?", November 2012. Note: we have not carried out a detailed review of the GSMA and Deloitte methodology; a purposeful triangulation of the take-up to GDP per capita growth and traffic to GDP per capita growth parameters, with a view of specific markets and timeframes, may alter the modelling results presented within this report.

In order to assess the value of existing investments, the above methodology is applied to a forecast period, comparing base-level traffic projections with scenarios in which Facebook's edge is "switched off", i.e. when traffic enabled by Facebook's caches and PoPs is excluded. To produce results for the overall region, this methodology is followed for individual countries in sub-Sharan Africa, noting that modelling assumptions vary depending on cache and PoPs in a given country, its distance to the regional hub, and the level of international connectivity available.

By applying the relationship between growth in traffic per user and growth in GDP per capita it is possible to calculate new rate of growth in GDP per capita and new total GDP, and a comparison of the resulting values to base-line GDP yields the share of GDP growth enabled by edge investments. The cumulative value of this additional GDP comprises the economic value of the initiatives.

A.2 OTNx

The economic impact of OTNx is assessed by estimating the incremental increase in mobile Internet take-up resulting from the initiative and using the relationship between this increase and GDP (based on findings from third-party studies) to measure the economic value of the initiative.

The following steps are taken to carry out this assessment (illustrated in Figure A.4 below).

- **Step 1:** At a national level for each country, the population coverage of 3G+ technologies and penetration of unique mobile Internet users are used to derive the national level of mobile broadband take-up within areas that have coverage.

- **Step 2:** For each country, the population covered by each OTNx initiative is known. The areas where fibre backhaul has been deployed are assumed to not have had any prior 3G+ connectivity. As a result of OTNx, it is assumed that mobile broadband take-up in the area concerned will reach the national level (derived as per Step 1 above) within three years of the launch of the initiative, with the first users obtaining access to mobile broadband in the year of launch.

- **Step 3:** In the counterfactual scenario (with no Facebook initiative), it is assumed that the first users will obtain access to mobile broadband three years later than would be the case with OTNx, and that it will take five years for take-up in the area to reach the national level. Therefore, the main impact of Facebook's initiative is to shift the mobile broadband penetration curve earlier in time, which results in incremental penetration increase from the year the initiative is launched until the year when the two scenarios converge.

- **Step 4:** The derived delta in mobile broadband take-up (difference in take-up levels with and without OTNx) is applied to the number of affected Internet users and a blended national average is calculated, obtaining the impact on mobile broadband penetration at the national level.

- **Step 5:** According to the most recent ITU study from 2019, a 10-percentage point increase in mobile broadband penetration in a given country results in a 2.5% increase in GDP per capita for this country (based on coefficients derived specifically for the African region).[45] The relationship established in the ITU study is therefore used to calculate the overall GDP impact of a given Facebook OTNx initiative.

A.3 Express Wi-Fi

The Express Wi-Fi initiative achieves two connectivity outcomes:

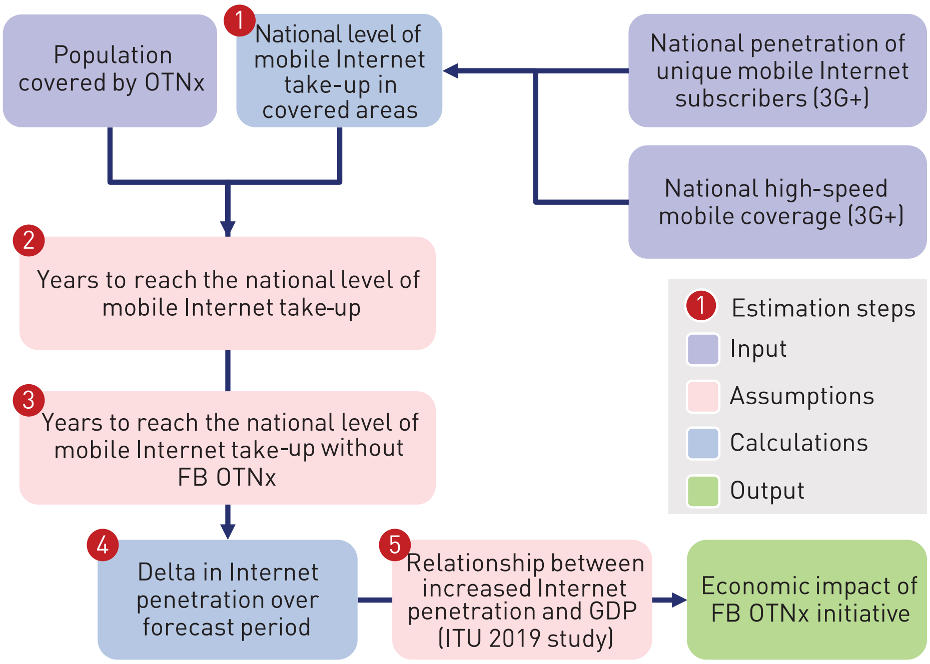
- **increased Internet take-up –** Express Wi-Fi enables Internet access for people who were previously unconnected

- **increased data traffic –** Express Wi-Fi users have been found to have above-average levels of data consumption for mobile broadband users.

The impact of the Express Wi-Fi initiative can therefore be assessed by quantifying both of these connectivity outcomes and using the relationship between these outcomes and GDP (established by third-party studies) to measure the final economic value.

[45] ITU – The Economic contributions of broadband, digitization and ICT regulation, 2019.

FIGURE A.4: CALCULATING THE ECONOMIC IMPACT OF FACEBOOK'S OTNX INITIATIVES [SOURCE: ANALYSYS MASON, 2020]



The following steps are involved in such an assessment (illustrated in Figure A.5 below):

- **Step 1:** For each country, monthly active users of the Express Wi-Fi service are known. It is assumed that the number of users will grow by 5% per year. It is estimated that around 20% of those Express Wi-Fi users are "new to Internet", i.e. they did not previously have meaningful connectivity. This is used to estimate the number of Internet users who received meaningful connectivity as a result of Express Wi-Fi in a given year.

- **Step 2:** For the traffic impact quantification, an average Express Wi-Fi user is estimated to consume approximately 1.5 times more data per month than the average mobile broadband user at the national level. This uplift is applied across all countries to derive their respective Express Wi-Fi data usage; the uplift coefficient is kept constant throughout the forecast period.

- **Step 3:** The incremental traffic increase for a country is then calculated, in two stages.

1) The delta in data usage (difference between Express Wi-Fi and regional average data usage levels) is multiplied by the number of Express Wi-Fi users who would have access to the Internet even without Express Wi-Fi

2) Express Wi-Fi data usage is multiplied by the number of Express Wi-Fi users who would not otherwise have Internet access.

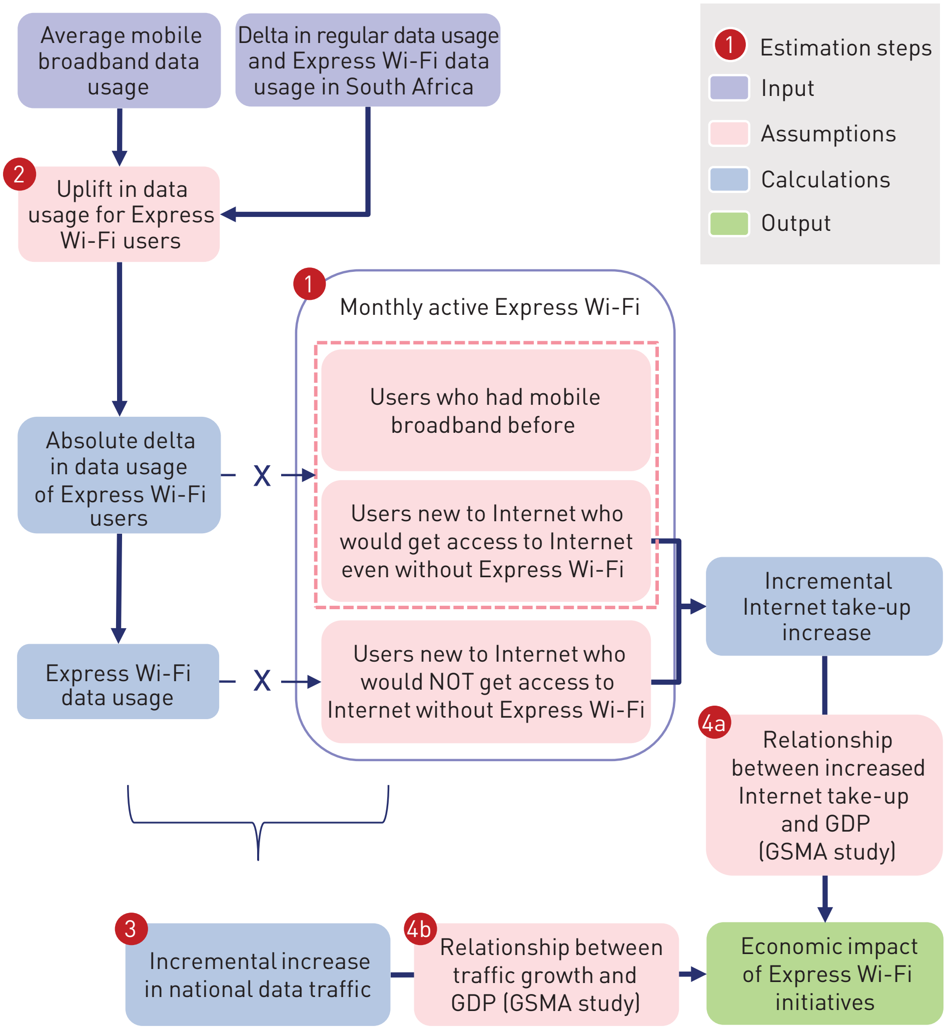
- **Step 4:** According to a GSMA study of the impact of mobile telephony on economic growth (Williams et al, 2012), if 3G mobile penetration for a given country increased by 10 percent within 3 years this would result in a 0.15 percentage point increase in its annual growth rate for GDP per capita.[46] For the purposes of this analysis, it is assumed that effect of 3G/4G take-up increase has the same effect.

According to the same study, if a country doubles its mobile data usage within 5 years, this results in a 0.5 percentage point increase in its annual growth rate for GDP per capita.

Therefore, the relationships established in the GSMA study are used to calculate the overall GDP impact of Express-Wi-Fi for each of the countries concerned.

[46] GSMA, Deloitte – "What is the impact of mobile telephony on economic growth?", November 2012; See: https://www.gsma.com/publicpolicy/wp-content/uploads/2012/11/gsma-deloitte-impact-mobile-telephony-economic-growth.pdf. Note: we have not carried out a detailed review of the GSMA and Deloitte methodology; a purposeful triangulation of the take-up to GDP per capita growth and traffic to GDP per capita growth parameters, with a view of specific markets and timeframes, may alter the modelling results presented within this report.

FIGURE A.5: CALCULATING THE ECONOMIC IMPACT OF FACEBOOK'S EXPRESS WI-FI INITIATIVES
[SOURCE: ANALYSYS MASON, 2020]



Annex B Demand-side initiatives

This annex provides an additional case study on Facebook initiatives aimed at stimulating demand for connectivity.

Free Basics

Free Basics is an online platform that Facebook has deployed in partnership with MNOs to provide access to low-bandwidth services without data charges. Services that are available through the platform are provided by website developers, non-profit organisations and governments, and include content such as news, employment, health, education and local information.[47]

The Free Basics platform is open to any developer who submits a site as long as the site meets the programme's technical criteria (e.g. no video or large photos).[48] Free Basics is also non-exclusive so that any mobile operator can choose to participate. Mobile operators are not paid to offer Free Basics, and developers are not charged to have their sites included in the programmes.

By enabling people to access the benefits and relevance of connectivity without data charges, Free Basics is designed to help bring people online and transition them to regular use of the broader internet. Free Basics also provides a baseline of connectivity intended to help people stay connected consistently and incentivised to continue purchasing data to stay on the internet when they are able to do so.

Free Basics is deployed in at least 27 countries within sub-Saharan Africa, and more than 55 countries around the world.

[47] Facebook connectivity, Free Basics, see https://connectivity.fb.com/free-basics/

[48] See https://developers.facebook.com/docs/internet-org/platform-technical-guidelines/.

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