Google

Equiano

Economic Impact Assessment

Togo

This assessment was commissioned by Google and delivered by Africa Practice based on economic modelling assistance from Genesis Analytics. It provides an overview of Togo's connectivity ecosystem and highlights Equiano's expected key impacts on the economy, job creation and sustainability. This report is accompanied by a technical annex that details the methodology and assumptions adopted in this assessment, as well as the underlying economic modelling and analysis.

Africa Practice
Africa Practice is a strategic advisory firm operating at the nexus of industry and government since 2003. It advises corporations, investors, and foundations across Africa, enabling them to drive sustainable and equitable development.

Genesis Analytics
Founded in 1998, Genesis Analytics was one of the first economics-based consulting firms in Africa. It uses its technical capabilities to improve decision-making and unlock substantial value for clients and society.

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Executive summary

Equiano – a next-generation subsea internet cable funded by Google – will run from Portugal to South Africa, along Africa's Atlantic Ocean coastline. In 2022, it is expected to land in Sesimbra (Portugal), Lomé (Togo), Lagos (Nigeria), Swakopmund (Namibia) and Cape Town (South Africa), with branching units in place for further phases of the project. Last year, the cable landed in Ruperts Bay (Saint Helena).

Globally, sub-Saharan Africa remains the most underserved region in terms of internet infrastructure. Penetration stands at 29%, while for the entire continent (including North Africa), it is 40%. According to the Broadband Commission for Sustainable Development, USD 100 billion in private and public investment is needed to achieve universal and affordable access to good quality broadband in Africa by 2030.

In Togo, the share of people using the internet stands at approximately **23%** as of 2020 – double what it was in 2016. Across much of the country, people lack access that is affordable, reliable and of good quality. Poor connectivity hinders economic growth, poverty reduction, human development and progress towards the Sustainable Development Goals.

Equiano will have a direct impact on connectivity in Togo following its landing, resulting in faster internet speeds, improved user experience, and reduced internet prices. Internet speeds in the country are expected to more than double from **10 Mbps** in 2021 to **21 Mbps** in 2025, while retail internet prices are forecast to decline by **14%** over the same period. Improved speeds and lower prices are expected to boost penetration by **5.1 percentage points** over this period.

By increasing international bandwidth, Equiano will indirectly broaden access to the internet in Togo, thus contributing to narrowing the digital divide within the country, as well as between Togo and other regions that currently have more developed connectivity infrastructure.

Africa's digital transformation and its internet economy - projected to grow from USD 115 billion in 2020 to USD 180 billion in 2025 and USD 712 billion by 2050 - depend on well-developed connectivity infrastructure. Strong connectivity and more affordable and reliable internet access can help Togo diversify its economy away from historically dominant sectors, such as agriculture, unlocking new pathways to collective prosperity. For Togo's population, businesses, and government, the digital economy can be a gamechanger and a key lever to accelerate growth, industrialise, innovate and improve people's lives.

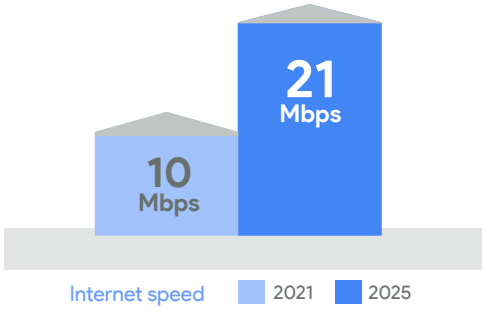
Between 2022 and 2025, average year-on-year real growth in Togo is expected to increase by **0.50 percentage points** due to Equiano. By 2025, real GDP in the country is forecast to be higher by USD 193 million than it otherwise would have been without the cable. Between 2022 and 2025, Equiano is expected to lead to an additional **USD 351 million** in total economic output in Togo.

Improved connectivity also accelerates job creation. Between 2022 and 2025, Equiano should indirectly create **36,870 new jobs** – equivalent to **9,200 per year** over the assessment period – driven by the expansion of the digital economy and peripheral sectors.

Equiano's key impacts in Togo

A boost for connectivity

Average internet speeds are set to rise following Equiano's landing



Equiano will also result in major price reductions for consumers, improving affordability of access

Decline in internet retail prices (2021 - 2025)

Improved speeds and affordability will result in greater internet penetration

Increase in internet penetration (2021 - 2025, % points)

A catalyst for growth, job creation and sustainability

By 2025, real GDP expected to be higher than it otherwise would have been by:

USD 193 million

Equiano will boost job creation (2022 - 2025)

36 870 jobs

Tonnes of CO_2 emissions to be saved (2022 - 2025)

15 kilotons

Togo's connectivity ecosystem

The case for investing in Togo's telecommunications infrastructure

The digital divide

The majority of Togo's population lives without internet access that is affordable, reliable and of good quality. As outlined below, internet access in Togo is among the least affordable on the continent, hindering uptake and limiting the country's digital potential. 3G and 4G mobile coverage is also underdeveloped relative to Togo's neighbours Ghana and Benin, limiting access to high-speed internet.

Investments in terrestrial fibre infrastructure have historically been relatively low due to the country's small domestic market and the concentration of economic activity on the coast, which limits the commercial imperative to broaden access in the interior.

In addition to these infrastructural constraints, limited digital skills development in the education system – aside from in higher education establishments, where the government has made significant progress - hinder the uptake of digital technologies. Likewise, the high costs of internet-enabled devices in relation to local incomes frustrate the development of the digital economy.

A young and growing population

Togo has one of the world's youngest populations with a median age of 19.4 years in 2020. 60% of the population is under 25 years, while people under the age of 14 account for 40% of the overall population.

Togo's need for improved connectivity is based not only on the current digital divide, but - more importantly - on future gaps.

By 2050, the population is expected to almost double and reach 15.4 million, up from 8.2 million as of 2020. Deepened investments in connectivity infrastructure will be central to ensuring future generations have reliable and affordable access to the internet and can leverage the opportunities access unlocks.

An enabling policy environment

While Togo has historically suffered from limited international connectivity as a result of its small economy and small coastline, the government has demonstrated a sustained interest in addressing this.

THE DIGITAL ECONOMY: A KEY PRIORITY FOR TOGO

The Togolese government has actively prioritised the digital economy as part of its development ambitions. Two-thirds of the projects detailed in the National Development Plan (PND)[1] covering 2018 to 2022 have a digital dimension. One of the PND's three fundamental pillars - establishing Togo as a first-class business centre in West Africa - hinges on the development of the digital economy and services.

The PND's digital objectives are operationalised through the Digital Economy Sector Policy Statement, which covers the same time frame. It aims to establish Togo as a regional service hub and an international centre for digital innovation and expertise. Its key objectives include:

- Achieving broadband (10 Mbps+) internet access for over 90% of the population and more than 95% of businesses
- Placing Togo in the top ten African countries on the main indicators for digital readiness (i.e. Network Readiness Index, ICT Development Index, UN e-Government)
- Reaching a digital sector turnover of FCFA 400 billion (USD 700 million), equivalent to at least 10% of GDP

Togo has devised four pillars to achieve these targets:

- Developing local, national and international infrastructure
- Promoting ICT in the broader economy and increasing access for the most vulnerable
- Enhancing competition in all market segments
- Ensuring national digital sovereignty, including cybersecurity and protection of citizens

The Digital Togo Strategy 2025 is expected to accelerate digital transformation in the public administration and private sector in the years to come, leveraging recent gains in connectivity.

1. Togo, 2018, National Development Plan (PND) – 2018 -2022.

In 2013, Togo mobilised USD 30 million in support from the World Bank's USD 300 million West Africa Regional Communications Infrastructure Project (WARCIP) to boost connectivity. Work on the country's first data centre and virtual landing point (VLP) in Lomé began in 2018, funded by WARCIP. The USD 23.7 million Lomé Data Centre was inaugurated in June 2021. The Tier III facility includes 400m² of servers open to the private sector and 100m² reserved for the government. The data centre is managed and operated by Liquid Intelligent Technologies subsidiary Africa Data Centres on behalf of the government.

In May 2021, Togo secured USD 11 million in additional financing under WARCIP to:

- Complete the construction of the national carrier hotel[2] that acts as a national and regional hub which buys and resells international bandwidth capacity on Togo's wholesale broadband market
- Address policy, market and regulatory bottlenecks that hamper connectivity
- Help the government elaborate its Togo Digital Strategy 2025

Sector diagnostic: taking stock of Togo's connectivity infrastructure

The following section provides an overview of Togo's connectivity infrastructure, detailing the country's current and future submarine links, current IP transit pricing, terrestrial infrastructure and internet coverage, as well as speeds.

International connectivity links

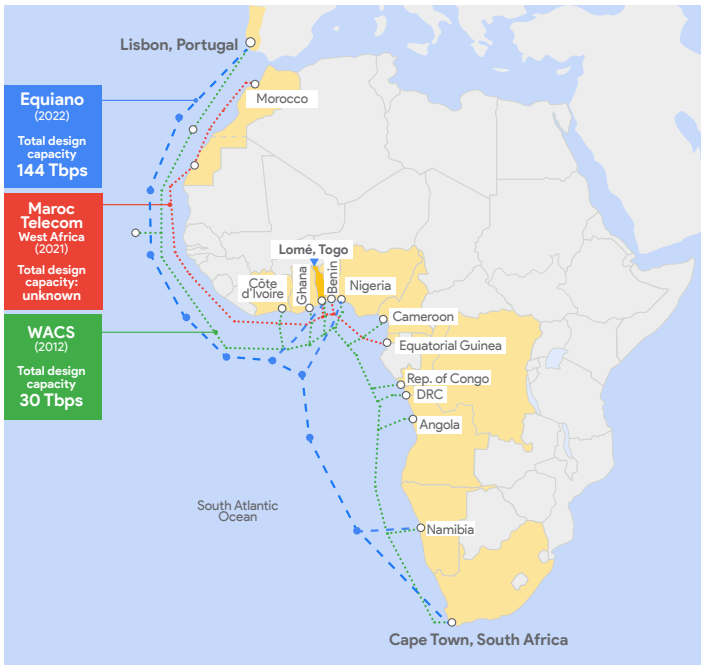
Togo's relatively small economy and limited coastline of 51 kilometres have hampered the development of international submarine connectivity. The country currently has one subsea cable, the West Africa Cable System (WACS) which landed in 2012, and satellite-based broadband connections offered by several ISPs. In comparison, neighbouring Ghana is connected to five cables, while Benin has two submarine links.[3]

WACS has a total design capacity of 30 Tbps and a lit capacity of 3.92 Tbps, equivalent to 13% of the total design capacity.[4] In the short term, two additional subsea cables are set to land in the country: Maroc Telecom West Africa and Equiano.

The Maroc Telecom West Africa cable is to be constructed by Maroc Telecom's Moov Africa,[5] linking Morocco to Côte d'Ivoire, Togo, Benin and Gabon.[6] It will complement Maroc Telecom's existing Trans-Africa network, which runs overland from Western Sahara through Mauritania, Mali and Burkina Faso to the borders with Côte d'Ivoire, Togo, Benin and Niger. Progress towards its completion is unclear as of January 2022 - initially it was expected to be ready for service in August 2021.

2. Also known as a colocation centre.
3. Ghana's economy is almost ten times larger than Togo's, while Benin's is almost double the size.
4. TeleGeography, 2021, Global Bandwidth Research Service.
5. In 2021, Maroc Telecom rebranded its 11 African subsidiaries as Moov Africa.
6. TeleGeography, 2021, Global Bandwidth Research Service.

FIGURE 2 : Installed and soon-to-be installed subsea cables in Togo



Source: TeleGeography, 2022, Submarine Cable Map.

CABLE DAMAGE AND DISRUPTION TO CONNECTIVITY IN TOGO

In recent years, several cables connecting to West Africa have experienced physical damage mainly due to weather, other natural conditions and fishing vessels, resulting in major disruptions to services. These incidents have had a major impact even in countries which are connected to several cables, such as Nigeria. In 2009[7] and 2011,[8] damage to the SAT-3/WASC cable significantly affected telecommunications in Togo for a

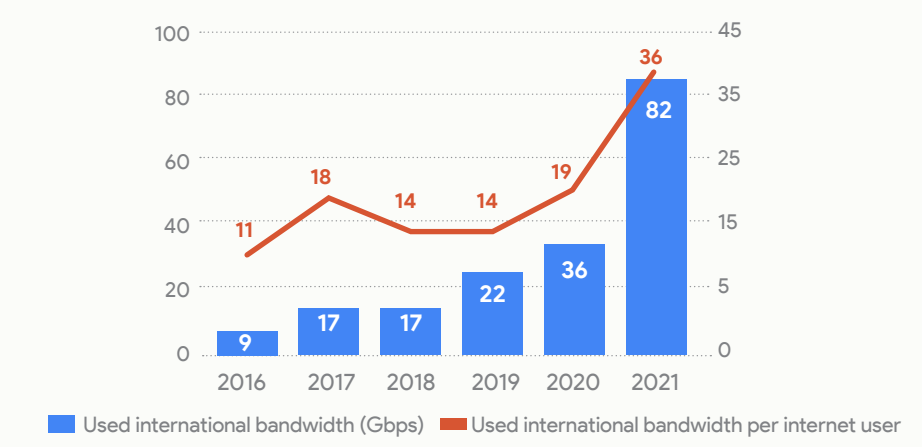
At the time, Togo did not have its own submarine cable, instead relying on terrestrial links from neighbouring Ghana and Benin - both connected to SAT-3/WASC.

In January 2020, Togo, and the wider region, experienced further significant disruption, following damage to the WACS, which left businesses and users unable to access reliable internet.[9]

Having a diversity of cable routes and landing stations provides safety in numbers. The landings of Equiano and the Maroc Telecom West Africa cable will provide Togo with additional network redundancy, ensuring better stability of bandwidth connectivity, as well as lower latency and higher speeds in the long-haul transmission of data.

Togo's used international bandwidth capacity is relatively low at 82 Gbps (see Figure 3). Between 2020 and 2021, used international bandwidth capacity increased by a year-on-year average of 56%.[10]

FIGURE 3 : Used international bandwidth capacity in Togo 2016 - 2021

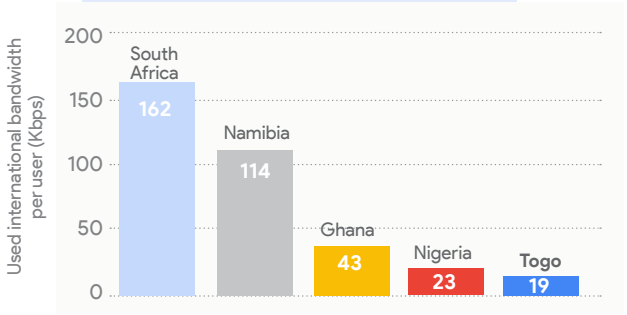


Source: TeleGeography, Global Internet Geography, Regional Analysis, 2021 | Authority for the Regulation of Electronic Communications and Post, Electronic Communications Market Observatory, Quarterly Reports, 2017 Q3 - 2020 Q4 | Genesis Analytics, 2022, team analysis

7. BBC, 2009, Large parts of West Africa are struggling to get back online following damage to an undersea cable.
8. Reuters, 2011, Togo struggles to get back online after cable fault shut down much of West Africa.
9. Togocom, 2020, Communiqué Togocom: coupure d'internet.
10. TeleGeography, 2021, Global Bandwidth Research Service.

Togo's relatively low used international bandwidth capacity is also mirrored at the internet user level. The country's used international bandwidth per user in 2020 was approximately nine times less than in South Africa and about half of Ghana's (see Figure 4). Between 2016 and 2021, capacity per user in Togo grew by a 28% year-on-year average.

FIGURE 4 : Comparison of used international bandwidth capacity per user in selected African countries (2020) 2020

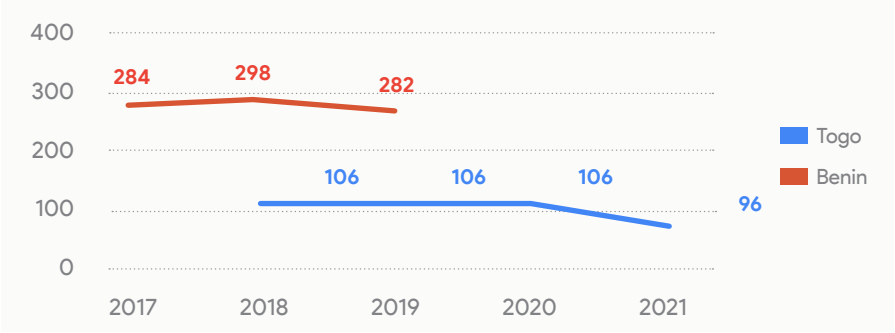


Source: TeleGeography, 2021, Global Internet Geography, Regional Analysis | Genesis Analytics, 2022, team analysis

International bandwidth pricing

Average wholesale internet prices in Togo have remained stagnant over the last four years, based on an analysis of Togo Telecom's IP transit prices. The operator's average annual IP transit prices were constant between 2018 and 2020, only declining by 10% in 2021, as shown in Figure 5. Similarly, wholesale internet prices in neighbouring Benin have remained relatively stagnant. The number of subsea cables installed in Benin (two) and Togo (one) has remained the same since 2012, which may explain the stickiness of IP transit prices in both markets.

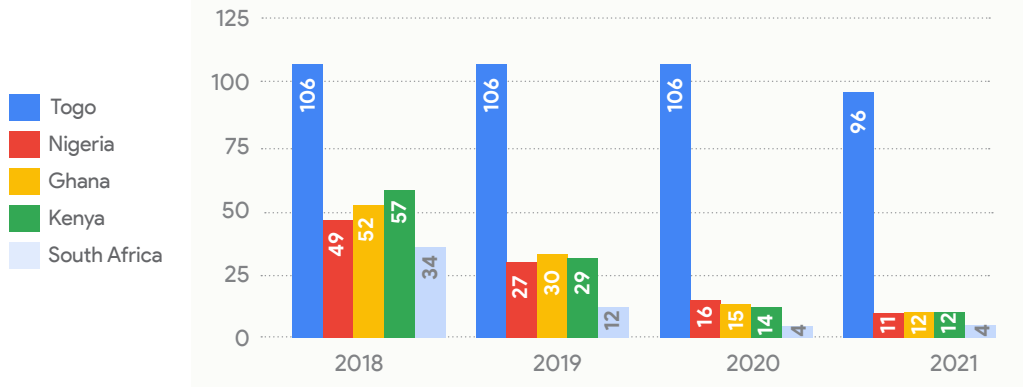
FIGURE 5 : Average IP Transit prices in Togo and Benin (USD / Mbps / Month)



Source: Togo Telecom, 2021, Services d'interconnexion et d'accès – Catalogue 2021; TeleGeography, 2021, Pricing Suite

Togo's IP transit prices are high compared to other African markets, as illustrated in Figure 6. High IP transit prices are likely one of the key drivers of relatively high internet retail prices in Togo. As noted in a World Bank study from 2016,[11] between 50% and 80% of the final cost of internet access to consumers could be attributed to the high cost of international bandwidth in Togo.

FIGURE 6 : IP transit prices in Togo and selected African countries (USD / Mbps / Month) 2018 - 2021



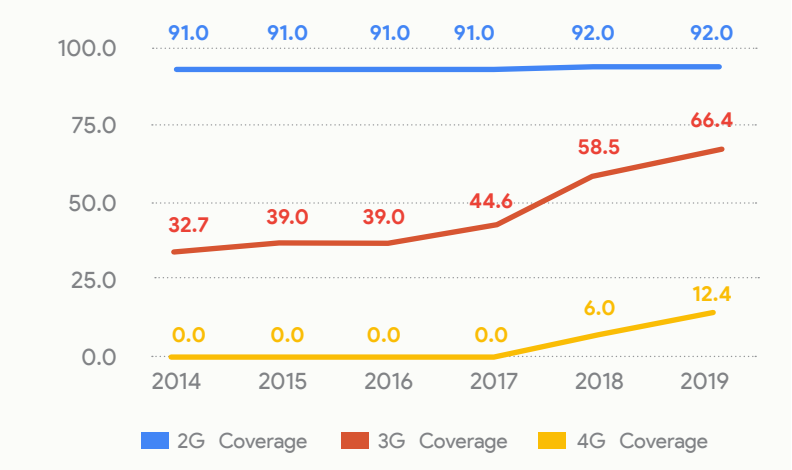
Source: TeleGeography, 2021, Pricing Suite - IP transit prices, database | Genesis Analytics, 2022, team analysis

11. World Bank, 2016, Systematic Country Diagnosis – Togo.

Internet coverage

Mobile broadband coverage has increased steadily in recent years, with 3G coverage growing from 39% in 2016 to 66% in 2019, while 4G reached 12% of the population in 2019, following its introduction in 2017 (see Figure 7).

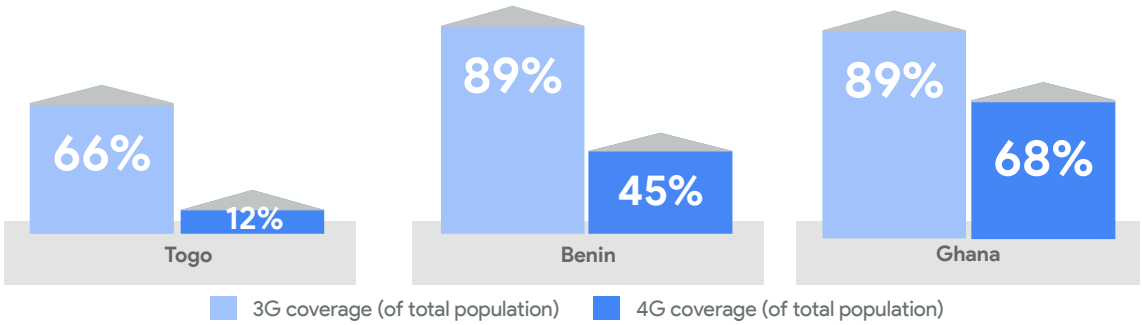
FIGURE 7 : Mobile broadband coverage in Togo (% of population) 2014 - 2019



Source: GSMA, 2021, Mobile Connectivity Index database

Despite the rollout of mobile broadband, Togo's 3G and 4G coverage lags behind Ghana's and Benin's, as shown in Figure 8. Limited market competition in Togo has undermined network coverage relative to its neighbours. Togo, however, became the first country in West Africa to launch commercial 5G services following the activation of Togocom's 5G network in partnership with Nokia in November 2020.[12] As of March 2021, the company had deployed 5G in three areas of the capital Lomé.

FIGURE 8 : 3G and 4G coverage in Togo, Benin and Ghana 2019



Sources: GSMA, 2021, Mobile Connectivity Index database

Internet speeds

Togo performs moderately well in terms of mobile broadband speeds, which averaged 19.3 Mbps for download between August and November 2021 and 4.4 Mbps for upload over the same period, according to Ookla.[13] The country is ranked 125th out of 177 for fixed broadband speeds. In January 2022, fixed broadband speeds stood at 16.4 Mbps for download and 2.9 Mbps for upload.[14]

12. Nokia, 2020, Nokia and Togocom deploy first 5G network in West Africa.
13. Ookla does not provide a ranking for Togo's mobile broadband speeds given countries require at least 300 unique user results.
14. Ookla, 2022, Global Index.

Using the internet

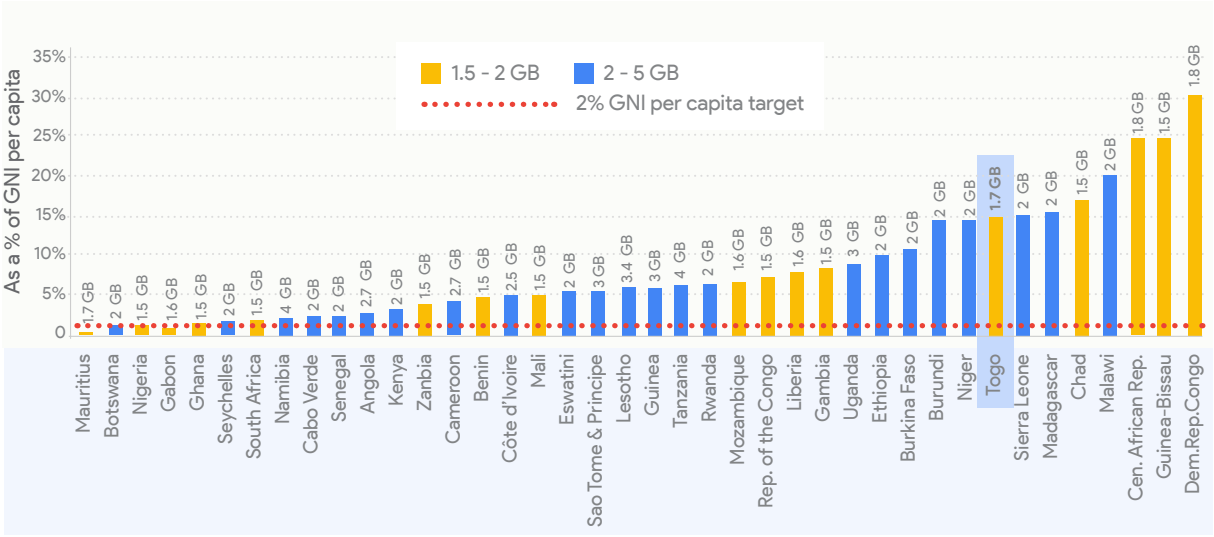
Improving the adoption of broadband, quality of access and - crucially - affordability has significant potential to accelerate Togo's socioeconomic development. The subsections below detail the country's connectivity infrastructure, highlighting key trends, progress and challenges.

Affordability

Figure 9 highlights mobile data prices as a percentage of Gross National Income (GNI) per capita. In Africa in 2020, only four countries - Mauritius, Botswana, Nigeria and Gabon - had mobile broadband baskets that meet the Broadband Commission's affordability target of 2% of GNI per capita. As shown below, Togo is among the countries in sub-Saharan Africa where internet access is the least affordable for consumers. This is likely driven by:

- A lack of competition in the submarine cable market, leading to high IP transit prices
- Limited, but growing, competition between mobile operators[15]
- Relatively low consumer purchasing power in relation to mobile tariffs

FIGURE 9 : Mobile data prices as a percentage of GNI per capita and monthly data allowance in Africa in 2020

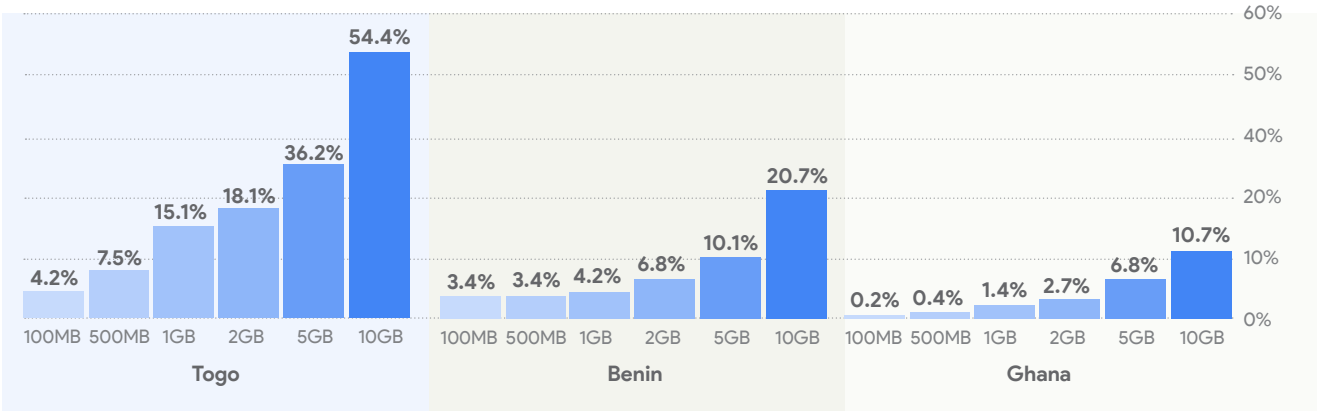


Source: ITU, adapted from "*Measuring Digital Development, ICT Price Trends 2020*"

Figures 10 and 11 below illustrate the affordability of mobile broadband in relation to average incomes and in absolute terms (USD). According to the International Telecommunication Union's ICT Price Trends reports, average mobile data prices in Togo in 2020 were about 2.5 times higher than in Nigeria and Ghana.[16] Moreover, Togo's mobile data prices relative to per capita income were approximately 4-5 times higher than the corresponding relative prices in Ghana and Nigeria.[17]

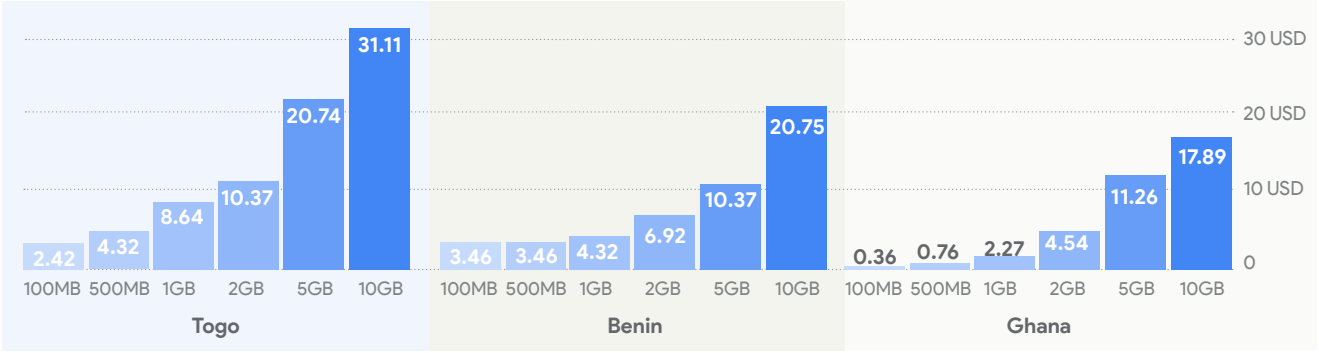
15. Togo has sought to attract a third network operator on several occasions over the last decade to boost competition, though has struggled to generate interest given the market's relatively small size. Le Temps, 2016, Téléphonie mobile : Pas de troisième opérateur au Togo.
16. ITU, Measuring digital development, 2020, ICT Price Trends.
17. Ibid.

FIGURE 10 : Affordability of mobile broadband bundles as a percentage of monthly average incomes 2020[18]



Source: Alliance for Affordable Internet, Mobile Broadband Pricing for 2020

FIGURE 11 : Affordability of mobile broadband bundles in USD 2020



Source: Alliance for Affordable Internet, Mobile Broadband Pricing for 2020

Figures 12 and 13 below show the prices for the cheapest 2GB of mobile data and unlimited fixed broadband[19] bundles between 2014 and 2020. In absolute terms, Togo's fixed broadband prices are similar to those of its neighbours, including Ghana and Nigeria.[20] However, owing to Togo's lower per capita income, fixed broadband prices relative to average incomes are higher than in Ghana and Nigeria.

FIGURE 12 : Monthly mobile broadband prices (2GB bundle)[21]

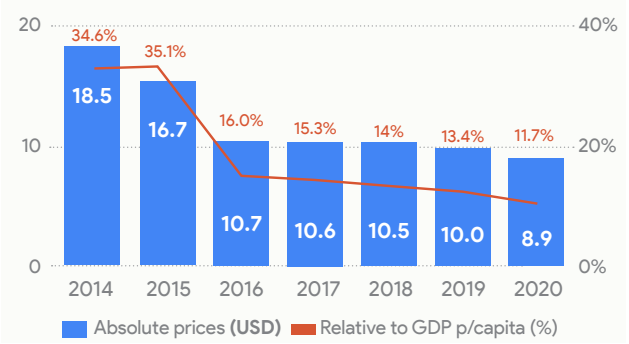
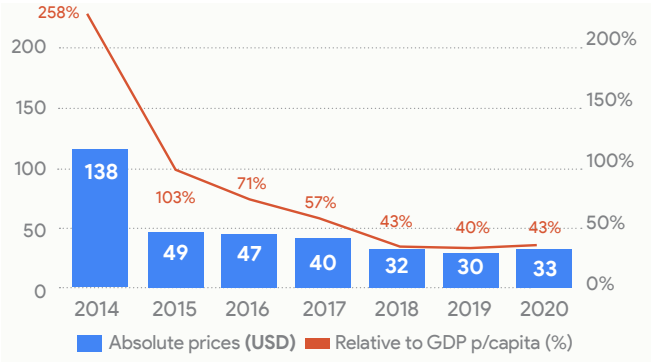


FIGURE 13 : Monthly fixed broadband prices



Sources: Regulatory Authority for Electronic Communications and the Post (Arcep - Togo), Communications Market Quarterly Review, 2017 - 2020 | Regulatory Authority for Electronic Communications and the Post (Arcep - Togo), Togo Telecom Tariffs, 2016 - 2014

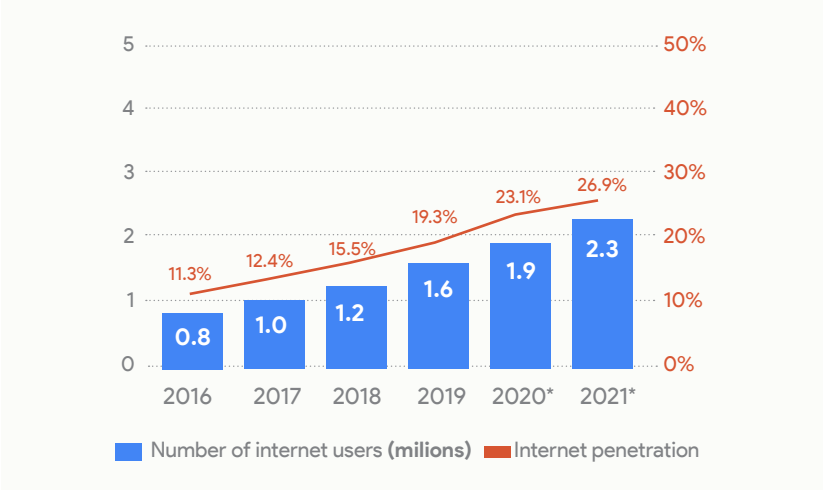
18. While the data from the Alliance for Affordable Internet (A4AI) in USD varies slightly from that provided by the ARCEP, the order of magnitude is the same. The A4AI data is particularly useful to establish international comparisons.
19. This corresponds to internet speeds of 20 Mbps between 2017 and 2020, and 1 Mbps prior to 2017.
20. While internet affordability is typically defined in relation to GNI per capita, GDP is a metric that can be used to forecast growth figures with greater confidence. We have therefore selected the GDP per capita metric to maintain consistency with Figures 21 and 22, which detail Equiano's impact on internet prices up to 2025.

Penetration and usage

Internet usage in Togo has grown rapidly in recent years as users increasingly leverage mobile technologies and connect to 3G and 4G networks. According to data from the Regulatory Authority for Electronic Communications and the Post (ARCEP), internet penetration doubled between 2016 and 2019, rising from 19.1% to 41.1%.

Between 2016 and September 2020, mobile broadband unique penetration more than doubled from 11% to 23%, as highlighted in Figure 14.[21] This metric is based on the number of mobile broadband *subscribers*, rather than *subscriptions* – and is therefore lower than the figures reported by the ARCEP.[22] Growth in the internet market is driven overwhelmingly by the mobile segment, with fixed line data penetration amounting to less than 0.5% in Q4 2020.[23]

FIGURE 14 : Number of internet users and internet penetration in Togo **2016 - 2021**



Sources: ITU, World Telecommunication/ICT Indicators Database | Genesis Analytics, 2022, team analysis
Note: *Forecast

Quality of service

Poor quality of service hinders user experience and the adoption of digital services. Togo's growing 3G and 4G coverage will help expand access to reliable, high-speed internet, which is key to unlocking the country's digital potential. The launch of 5G services has also boosted access to faster internet in Lomé. Meanwhile, the ARCEP is taking active steps to ensure operators conform to the quality of service standards outlined in their licences.

The regulator launched a real-time quality of service monitoring tool in June 2021,[24] which should boost its enforcement capacity and ensure consumers have access to reliable services.

21. World Bank, 2020, Digital Economy Diagnostic – Togo.
22. Some users may have several active mobile broadband subscriptions, which inflates figures as they are calculated by the ARCEP.
23. Regulatory Authority for Electronic Communications and the Post, 2020, Communications Market Quarterly Review – Q4 2020.
24. République Togolaise, 2021, L'Arcep ouvre un centre pour mieux contrôler la qualité de service des réseaux mobiles.

Equiano

A landmark investment in Africa

Bridging the divides: the critical role of submarine cables

Submarine cables are integral to achieving the above transformational objectives - they are the world's information superhighways and form the cornerstone of the internet. They carry an estimated 99% of global international communications and USD 10 trillion in daily financial transactions.[25] The remainder of international traffic is satellite-based. Highspeed, high-capacity connections - underpinned by submarine infrastructure - are central to today's hyperconnected global economy. Cables enable high-quality video streaming and conferencing, international phone calls, and support the growth of cloud computing.

A next-generation project

In June 2019, Google announced the subsea internet cable, Equiano, that would ultimately run from Portugal to South Africa along the Atlantic coast of Africa. The initial configuration of the cable system will include landings in Lomé (Togo), Lagos (Nigeria), Swakopmund (Namibia), Ruperts Bay (St. Helena), and Cape Town (South Africa) with branching units in place for further phases of the project. The first phase is expected to be completed in 2022.

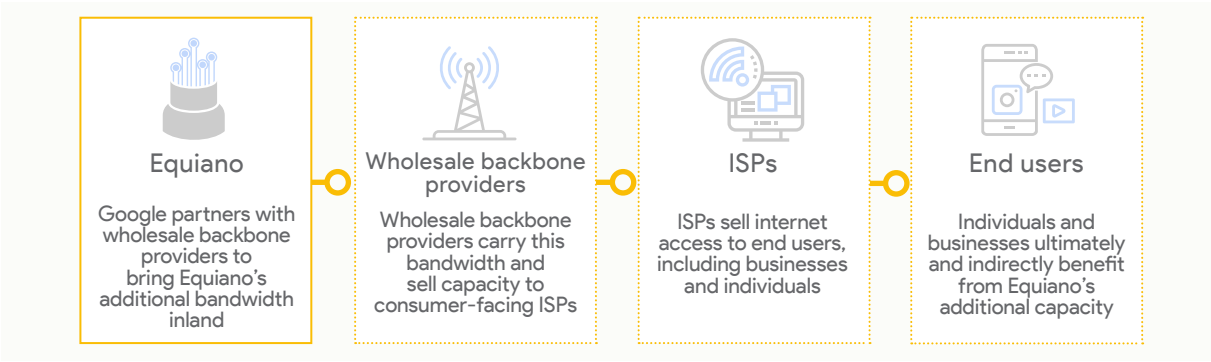
The next-generation Equiano cable will be the first subsea cable to incorporate optical switching at the fibre-pair level, rather than the traditional approach of wavelength-level switching. Equiano will also be the first spatial-division multiplexed (SDM) cable deployed along this route, allowing for a greater design capacity of 144 Tbps. The relative cost of deploying the Equiano cable with respect to its capacity will therefore be lower than the other cables built to date.

A cable system that serves the wider ecosystem's needs

While Google is spearheading the construction of the Equiano cable, other partners - namely wholesale backbone providers - will be able to use and benefit from the cable's additional capacity. Google does not directly provide broadband access to end users but instead partners with multiple key telecom players such as telcos or infrastructure operators where Equiano lands to ensure that the cable's additional capacity benefits the most end users and businesses across the continent (see Figure 15 below). This is achieved when key telecom players acquire capacity from the Equiano cable on an indefeasible right of use (IRU) basis. This allows Google's partners to benefit from Equiano's additional capacity over a pre-agreed, long-term time frame for their own use or to lease to third parties. Terrestrial infrastructure players may also avail their fibre routes to Google in exchange for a portion of Equiano's capacity.

25. Reuters, 2022, U.S. recommends approving Google, Meta undersea cable to Asia.

FIGURE 15 : How Equiano indirectly benefits end users



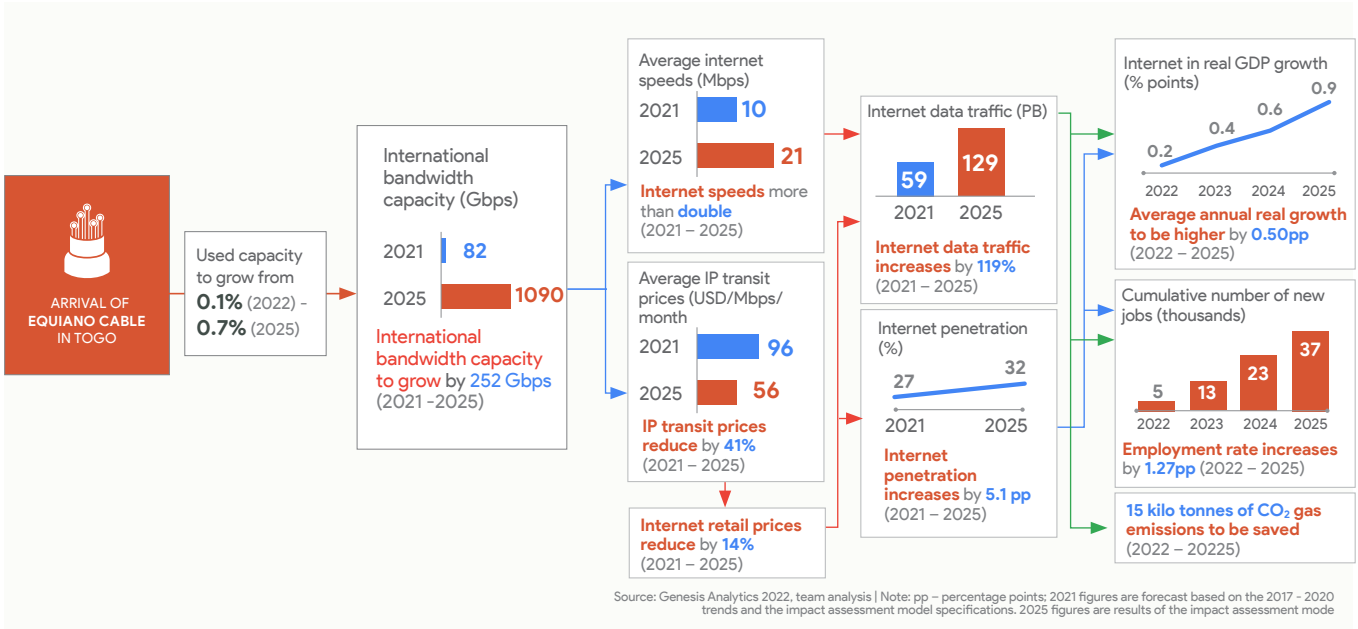
Source: Genesis Analytics, 2022

Equiano's cable landing stations will operate on an open-access and non-discriminatory model where all network players can interconnect with them if they wish to do so. By guaranteeing open access, Equiano aims to encourage more efficient and cost-effective equipment, ultimately resulting in better outcomes for consumers, businesses and the economy more broadly.

Equiano
A catalyst for connectivity

Equiano will have a direct impact on internet connectivity in Togo, resulting in faster internet speeds, lower latency, and lower wholesale and retail internet prices. The cable system will also spur higher economic growth and accelerate digital transformation, and is expected to contribute to a decline in greenhouse gas emissions. Figure 16 below provides a high-level overview of Equiano's expected impacts and their related pathways. The impact assessment model, assumptions and economic analysis are detailed in the technical annex.

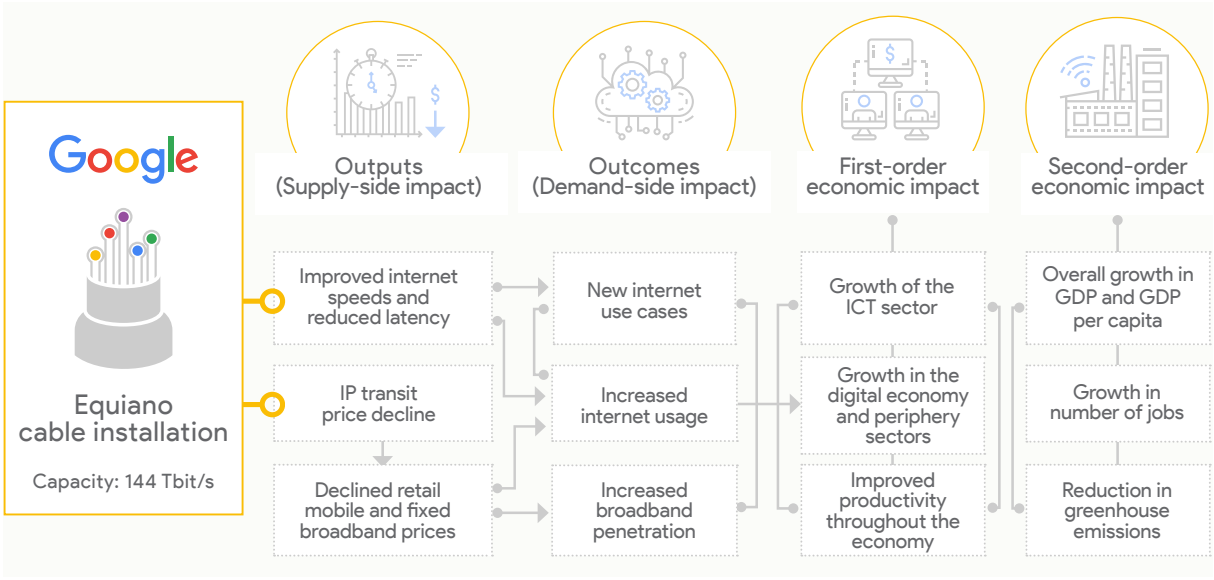
FIGURE 16 : Overview of Equiano's impacts 2021 - 2025



Source: Genesis Analytics 2022, team analysis | Note: pp – percentage points; 2021 figures are forecast based on the 2017 - 2020 trends and the impact assessment model specifications. 2025 figures are results of the impact assessment mode

These impact pathways are illustrated in Figure 17 and detailed in the following subsections. In-depth economic modelling and analysis is provided in a separate annex, along with a comprehensive literature review. The pathways show the successive impact of Equiano on the supply- and demand-side components of the internet market, the ICT sector, and the economy as a whole. This framework is based on existing literature concerning the impact of subsea cables on the supply and demand for internet broadband, as well as on literature on the impact of broadband on economic performance.

FIGURE 17 : Equiano's economic impact pathways



Source: Genesis Analytics, 2022

Changes in the supply-side metrics following Equiano's landing are expected to boost demand for, and uptake of, the internet by government, businesses and individuals. In turn, this will contribute to specific sectors benefiting directly from greater internet use, as well as boosting productivity in other sectors of the economy. These sectoral and productivity effects are the first-order economic impacts of the cable. Ultimately, they will lead to higher economic growth, greater job creation and a reduction in greenhouse emissions - the second-order economic impacts. Table 1 below expounds on these impact pathways, which are driven by:

- Faster internet speeds and reduced latency (pathway 1)
- More affordable internet access (pathway 2)

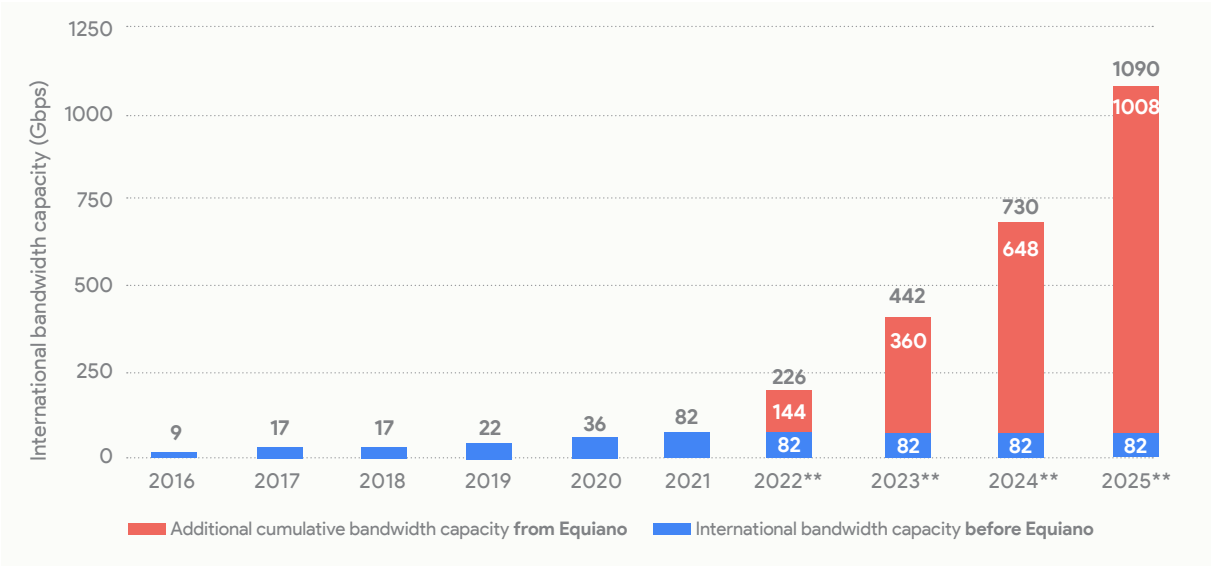
Table 1: Equiano's impact pathways and effects on the economy

	Supply-side impact	Demand-side impact	First-order economic impact	Second-order economic impact
Pathway 1	**Internet speeds and latency** The increased international bandwidth capacity from the Equiano cable means that more data can be transmitted within a given time frame. This will translate into faster internet speeds and lower latency, especially for non-cacheable content, and in areas with an established connection to the internet infrastructure backbone of the country.	Faster internet speeds and lower latencies are likely to enable new internet use cases, such as online learning and virtual conferencing, which have greater broadband requirements. Improved internet speed and latency will also result in greater internet usage demonstrated by greater data traffic.	Increased demand for and usage of the internet arising from increased penetration, growing adoption of new use cases and an overall increase in data traffic have the following immediate economic effects: • Growth of the ICT sector: greater demand and usage of the internet increases ISPs' revenues, induces the expansion of their networks and causes them to hire more labour, creating more jobs within the sector. • Growth of the digital economy and peripheral sectors: as more people increasingly provide and/or access services online and make transactions, internet penetration and usage increases, as does adoption of new use cases. Peripheral sectors such as transport and storage also experience growth as a result. • Improved productivity: increased adoption and usage of the internet will boost economic output with fewer resources. Examples of this are efficiencies in communication, payments and the various operational activities of businesses in a wide range of sectors. Such efficiencies lead to increased economic output within a shorter time frame.	Growth in the ICT sector, the digital economy and its peripheral sectors – as well as productivity improvements in the wider economy – enable: • Faster growth of GDP and GDP per capita. • Growth in the number of jobs in the economy. • Diversification of the economy away from agriculture. • Reduction in greenhouse emissions.
Pathway 2	**IP transit prices** The cost of long-haul transmission of data is a major determinant of local IP transit prices. The creation of an alternative long-haul transport route through the Equiano cable, together with the greater capacity of the cable, will directly (through a lower installation cost relative to design capacity) and indirectly (through increased competition for long-haul transmission of data) lower transmission and IP transit costs. The benefits of lower IP transit costs could in turn be directly passed on to consumers by ISPs through decreases in internet prices, or indirectly, through the provision of more data, uncapped data limits or higher speeds at the same price. Lower IP transit prices could improve ISPs' bottom lines, enabling them to invest in the expansion of their networks, thereby increasing coverage.	A reduction in retail fixed and mobile broadband prices will boost adoption and usage of internet through: • New internet subscribers (especially for fixed broadband) who previously could not afford the cost of a subscription. • Increased internet usage by subscribers who will be able to use more data at the same price or access higher internet speeds at a lower price. • Increased adoption of new internet use cases with high data requirements that had previously been too costly.		

Connectivity impact of Equiano

The increase in international bandwidth capacity following Equiano's landing (see Figure 18) is expected to have an immediate impact on average IP transit prices, speeds and latency. For end users in Togo, this will translate to cheaper and more reliable internet access, leading to a substantial growth in traffic and internet penetration.

FIGURE 18 : International bandwidth capacity in Togo **2016 - 2025**



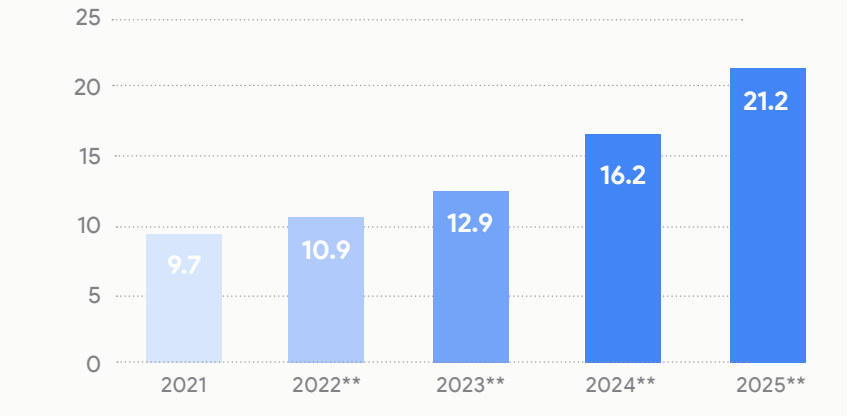
Sources: TeleGeography, 2021, Global bandwidth services | Genesis Analytics, 2022, team analysis
Note: **Equiano impact analysis period

Accelerating internet speeds

Investments in submarine cables boost internet speeds

The increased international bandwidth capacity from the Equiano cable means that more data can be transmitted to Togo within a particular time frame. This will translate into faster internet speeds and lower latency, particularly with regard to non-cacheable content, and in areas in close proximity to a terrestrial fibre optic cable.

FIGURE 19 : Average internet speeds in Togo (Mbps) **2021 - 2025**



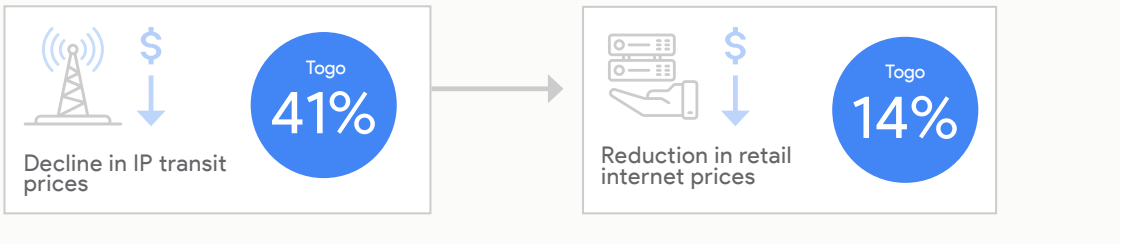
Source: Ookla, 2022, Global Index | Genesis Analytics, 2022, team analysis
Note: **Equiano impact analysis period

Making the internet more affordable

As detailed above, internet access in Togo remains significantly more expensive than the target set by the Broadband Commission. The cost of long-haul transmission of data is a major determinant of local IP transit prices. Equiano's landing in Togo will create a new, high-capacity route for international data transmission.

The cable's lower installation cost relative to design capacity, as well as increased competition for the long-haul transmission of data, will lead to lower IP transit prices. In turn, lower IP transit prices could be passed on to customers through decreases in internet prices, or indirectly - through the provision of more data, uncapped data limits or higher speeds at the same price.

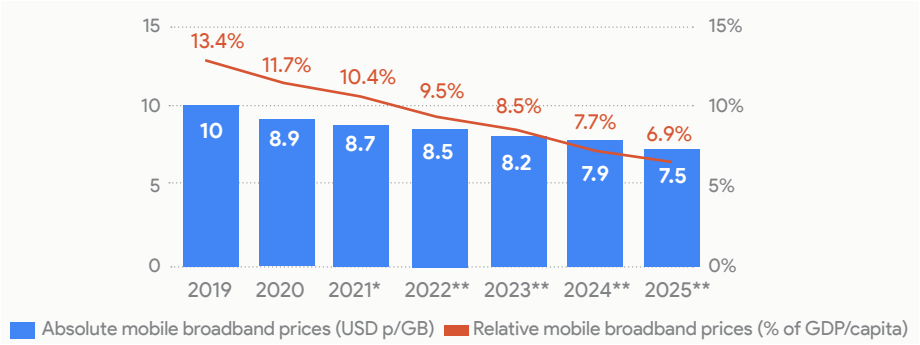
FIGURE 20 : Equiano's impact on internet prices **2021 - 2025**



Source: Genesis Analytics, 2022, team analysis

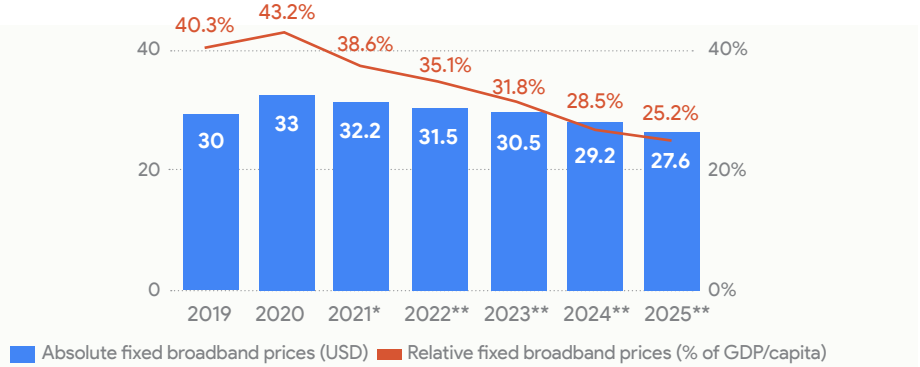
Figures 21 and 22 below illustrate the expected decline in average mobile and fixed broadband retail prices, immediately prior to and during the Equiano impact assessment period (2022-2025).

FIGURE 21 : Average mobile data retail prices[26] **2019 - 2025**



Sources: Regulatory Authority for Electronic Communications and the Post (Arcep - Togo), Communications Market Quarterly Review, 2020 - 2017 | IMF 2021, World Economic Outlook, | Genesis Analytics, 2022, team analysis. Note: *Forecast | **Equiano impact analysis period

FIGURE 22 : Average fixed broadband retail prices **2019 - 2025**



Sources: Regulatory Authority for Electronic Communications and the Post (Arcep - Togo), Communications Market Quarterly Review, 2020 - 2017 | IMF, World Economic Outlook, 2021 | Genesis Analytics, 2022, team analysis. Note: *Forecast | **Equiano impact analysis period

26. As mentioned earlier in the report, affordability is typically calculated in relation to GNI.

Boosting internet penetration and traffic

Lower prices, combined with improved speeds and latency, are expected to increase internet penetration in Togo by 5.1 percentage points between 2021 and 2025. Figure 23 below illustrates the two pathways which lead to this increase, while Figure 24 highlights the anticipated growth in the number of internet users and penetration following Equiano's landing.

FIGURE 23 : Lower prices and improved speeds increase internet penetration and improve user experiences

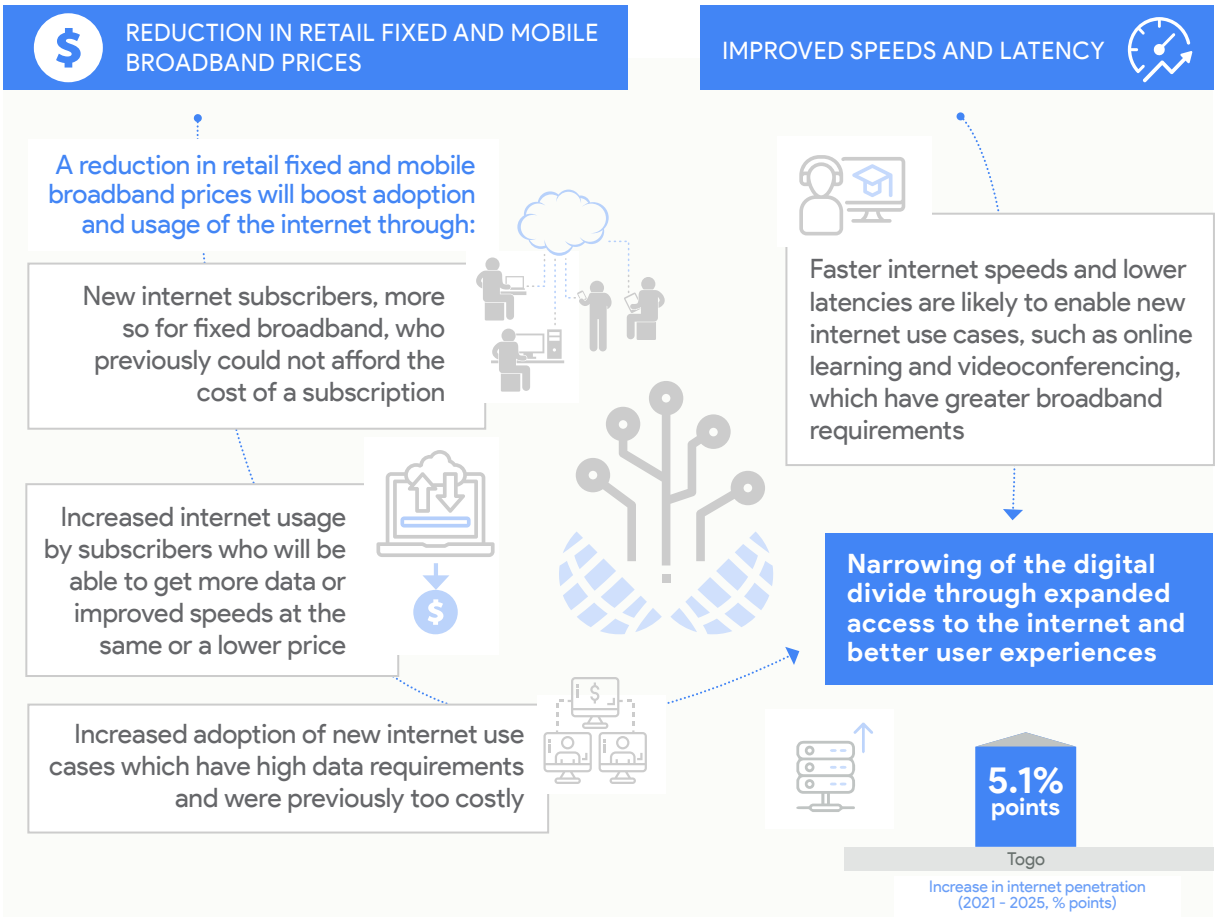
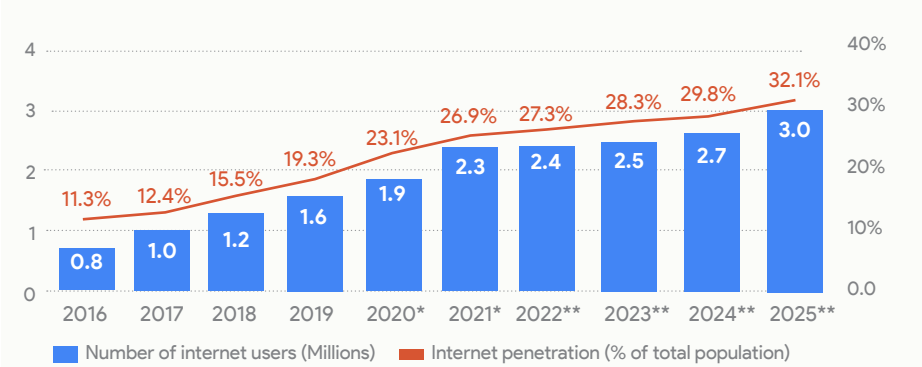


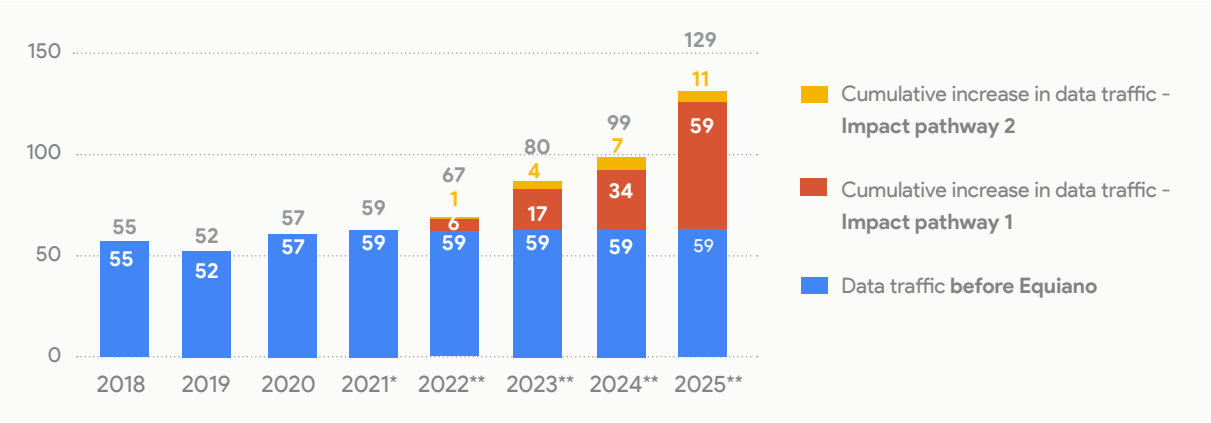
FIGURE 24 : Number of internet users and internet penetration in Togo 2016 - 2025



Sources: ITU, World Telecommunication/ICT Indicators Database | Genesis Analytics, 2022, team analysis
Note: *Forecast | **Equiano impact analysis period

Faster internet speeds will lead to a higher demand for data traffic. In parallel, lower internet retail prices will increase internet usage both extensively (by enabling new users to get online for the first time, as well as new ways of using the internet for existing users) and intensively (by enabling existing users to consume more data). The growth in total data traffic in Togo following Equiano's landing estimated from faster internet and more affordable access is illustrated in Figure 25 below.

FIGURE 25 : Total data traffic in Togo (PB) 2018 - 2025



Sources: Regulatory Authority for Electronic Communications and the Post (Arcep - Togo), Communications Market Quarterly Review, 2020 - 2017 | Genesis Analytics, 2022, team analysis
Note: *Forecast | **Equiano impact analysis period

Catalysing network expansion

Submarine cables' impact on speeds and prices described above can catalyse investments by ISPs and infrastructure operators, thereby expanding terrestrial networks. Specifically, lower IP transit prices following the landing of cables such as Equiano improve ISPs' bottom lines, enabling them to invest in the expansion of their networks to reach new customers.

In parallel, greater demand and usage of the internet following Equiano's landing is also expected to increase ISPs' revenues, inducing the expansion of their networks.

Cheaper and quicker internet underpins better user experiences

Improved speeds, lower latencies and more affordable internet bundles and subscriptions following Equiano's landing will support the types of users outlined in the table below. More reliable connectivity will improve the quality of their experience using latency-sensitive products and applications.

Table 3 : Internet use cases, minimum digital requirements and Equiano's impact

USE CASE	MINIMUM DIGITAL REQUIREMENTS	EQUIANO CABLE IMPACT
Online learning Some educational institutions in Togo, including the University of Lomé and its 60,000+ students, transitioned to a virtual learning experience as a result of the pandemic. **User profile:** Students, remote workers, job seekers, gig economy workers and migrant families.	1. A 1.5 Mbps Internet speed as a minimum requirement (both upload and download speed). 2. Institution platform, EDX, Coursera, Google Classroom, Google Meet, Zoom etc. Google Meet requires that outbound signals from a participant in all situations must meet a 3.2 Mbps bandwidth requirement for HQ video calls. The minimum requirement for SD video calls is 1 Mbps. 3. Educational materials require ~ 20 GB per month.	Internet speeds are set to more than double from 9.7 Mbps in 2021 to 21.2 Mbps in 2025, while retail internet prices are set to decrease by 14% within the same time frame. Through the value chain illustrated in Figure 15, Equiano will improve the ability of businesses and individuals to meet the minimum digital requirements for various use cases by: • **Delivering** more than the required speed and latency to enable good connectivity for all use cases. • **Improving** the bandwidth available to users in order to seamlessly access the digital tools for each of the use cases. • **Enabling** the acquisition of monthly data requirements for various use cases, more so for those requiring 20GB per month or less. • **Boosting** the adoption of the outlined use cases, giving more businesses and individuals access to an internet connection which meets the minimum digital requirements. • **Increasing** the intensive and extensive usage of the internet for these use cases.
Entertainment and gaming As individuals remain at home due to the COVID-19 pandemic, users are now increasingly using the internet for entertainment and live gaming. **User profile:** Students, remote workers, job seekers, gig economy workers and migrant families.	1. Netflix requires 3 Mbps for SD (standard definition) quality. YouTube videos can be streamed in standard definition for just 500 Kbps, with live events requiring at least 1 Mbps. Live gaming requires 10Mbps. 2. YouTube, Netflix and Showmax. 3. Videos, audio and games require ~ 100 GB per month.	
Job search and application A growing share of job recruitment processes are now conducted online from application to interview. **User profile:** Job seekers.	1. To search and complete job applications requires 500 kbps. Google Meet requirements as stated above. 2. Emploi.tg, Emploi Togo, Grow with Google, Google Meet, and Zoom. 3. Job forms and remote interviews require ~ 5 GB per month.	
Remote work Remote workers require high internet bandwidth and reliable internet connectivity. **User profile:** Students, remote workers, job seekers.	1. Google meet has a minimum 3.2 Mbps bandwidth requirement. 2. Google Workspace, Meet, Firebase, Slack, Adobe, call centre applications, Upwork etc. 3. Documents, coding, video and audio require ~ 100 GB per month.	
Gig economy work Gig economy workers include workers who provide a temporary service on digital platforms such as Gozem **User profile:** Gig economy workers	1. Internet bandwidth of ~500 Kbps to ~2 Mbps. 2. Gozem, Google Maps, Jumia. 3. GPS, audio, text, and voice call require ~ 20 GB per month.	
E-commerce and online business management Businesses require the internet to offer online retail services and manage operations. **User profile:** Businesses	1. WhatsApp Business required 64 Kbps and 500 Kbps for other business applications. 2. Jumia, Google Cloud, Google My Business, WhatsApp Business, Shopify. 3. GPS, audio, video, text, and voice call require ~ 20 GB per month.	
Remittances Remittances include local and cross-border payment to peers and merchants **User profile:** Students, remote workers, businesses, job seekers, gig economy workers and migrant families.	1. A minimum of 500 Kbps. 2. WorldRemit. 3. Payment rails (P2P, P2B, P2G, B2P, and G2P) require < 1 GB per month.	

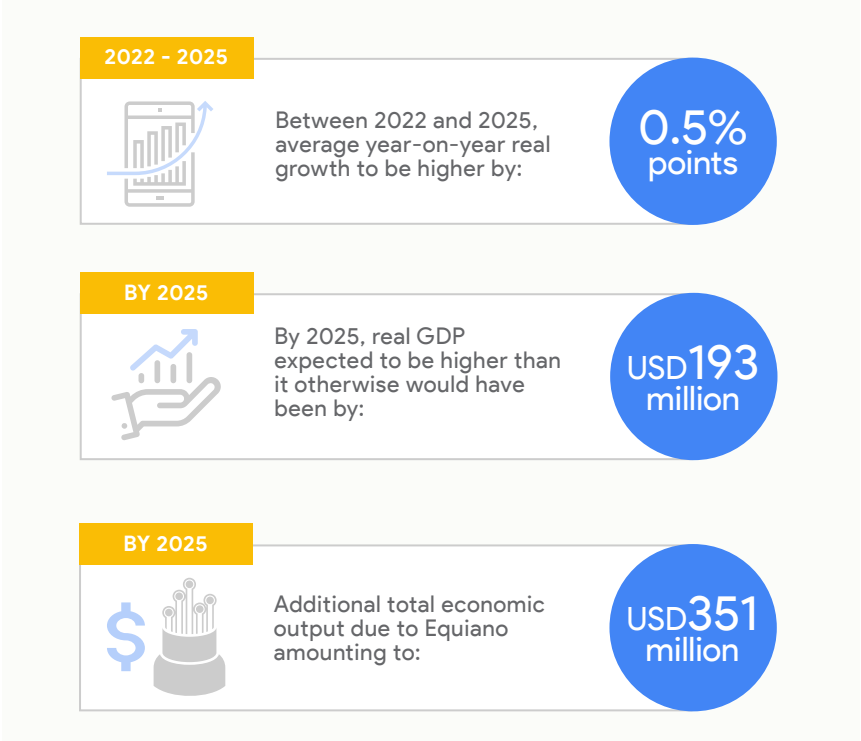
Macroeconomic impact of Equiano

Internet connectivity unlocks significant economic opportunities - more so in developing countries than their developed counterparts. A landmark study by the International Telecommunications Union in 2019 found that in Africa, a 10% increase in mobile internet penetration increases GDP per capita by 2.5%.[27] According to a separate study by the World Bank, achieving universal and affordable access to the internet across the continent would increase GDP growth by 2 percentage points per year and would boost employment opportunities by up to 13%.[28]

Boosting economic growth

More affordable and reliable internet access - following the landing of submarine cables such as Equiano - accelerates digital transformation and stimulates the digital economy, boosting GDP and growth rates.

FIGURE 26 : Equiano's impact on the economy



Source: Genesis Analytics, 2022, team analysis

Underpinned by reliable connectivity, the digital economy can be a game-changer for Togo's economy and society: it represents an opportunity to accelerate growth, industrialise, innovate and improve people's lives. This takes place through a wide range of mutually reinforcing and overlapping pathways, classified below by three key stakeholder categories:

27. International Telecommunication Union (ITU), 2019, Economic Contribution of Broadband, Digitization, and ICT Regulation: Econometric Modelling for Africa
28. World Bank, 2020, Togo: Could more digitalization be the solution?

At the individual level, broadband access plays a crucial role in developing human capital, which is essential for economic growth and competitiveness. It helps people acquire new skills and knowledge that are key to identifying and unlocking new employment opportunities. Improved connectivity also means better access to public services, as well as more affordable products and services from the private sector.

For businesses, broadband access lowers costs, raises productivity, drives innovation, introduces new processes and extends commercial links. Broadband also lowers the cost of international communications, thereby benefiting export-oriented firms. For information-intensive companies in the service sector (the knowledge economy), broadband is an integral part of business models. A wide range of sectors - such as fintech, e-commerce, healthtech, media and entertainment, local transportation, food delivery and business-to-business (B2B) e-logistics - are leveraging internet access and adoption to innovate and lead the way in the continent's digital transformation.

For governments, digital transformation can fundamentally improve the way the public sector operates - leading to more efficient service delivery in areas such as health, education or public administration. This, in turn, contributes to a more productive and efficient economy.

For Togo, attracting investments that boost connectivity and pivoting towards a digital-first economy offers an opportunity to diversify the country away from agriculture - the historically dominant sector. Leveraging ICT can unlock new pathways to collective prosperity, increasing government revenues and creating much needed economic opportunities.

Accelerating job creation

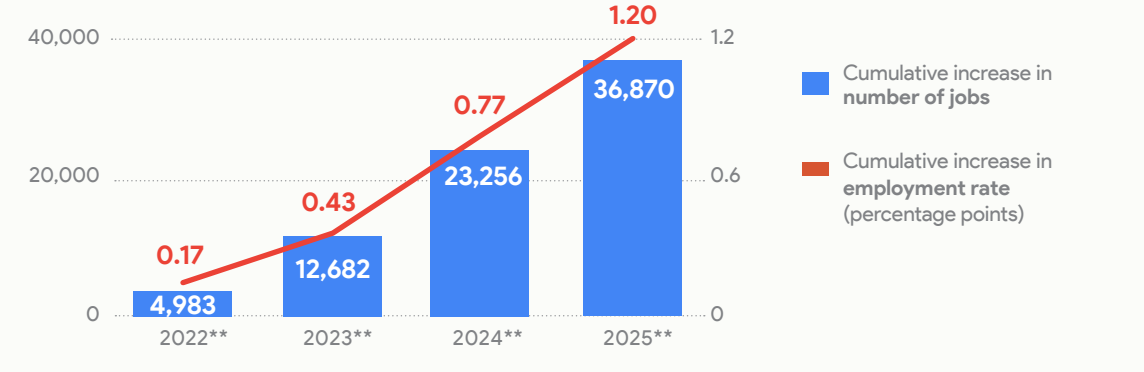
Between 2022 and 2025, Equiano is expected to indirectly create **36,870 new jobs** in Togo following the cable's landing. By 2025, the employment rate is expected to be **1.2 percentage points higher** as a result of Equiano, driven by two main pathways:

Growth of the digital economy and peripheral sectors.
The decline in internet retail prices and improved speeds lead to growing adoption by new users, and more intensive usage by existing ones. In turn, this facilitates the entry of new firms, particularly so in sectors that rely heavily on ICT such as finance and services. Peripheral sectors such as transport and storage also experience growth as a result of the development of e-commerce.

Growth of the telecoms sector.
Rising internet access boosts ISPs' and telcos' revenues, inducing the expansion of their networks, prompting them to hire more.

Figure 27 below illustrates expected job creation following the cable's landing and the associated increase in the employment rate.

FIGURE 27 : Increase in employment due to Equiano 2022 - 2025



Source: Genesis Analytics, 2022, team analysis
Notes: **Equiano impact analysis period

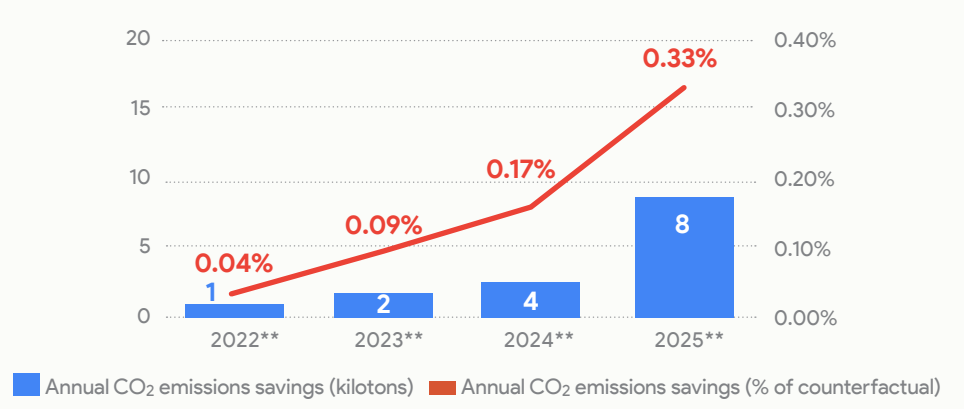
Sustainability impact of Equiano

Savings in CO_2 emissions and contribution to the SDGs

The expected increase in broadband penetration and adoption by consumers, businesses, government institutions and educational establishments is expected to lead to savings of CO_2 emissions, as a result of three main impact pathways:

Figure 28 below illustrates the cumulative savings in CO_2 gas emissions from Equiano, which amount to 15 kilotons between 2022 and 2025. These savings are relatively modest given Togo's CO_2 emissions are among the lowest in the world.

FIGURE 28 : Savings in CO_2 gas emissions from Equiano **2022 - 2025**



Source: Our world in data, 2021, annual CO2 emissions | Genesis Analytics, 2022, team analysis

More broadly, investments in connectivity can significantly accelerate progress towards achieving the UN's SDGs by 2030. The SDGs are a blueprint for a better and more sustainable future for all. SDG 17 - Partnerships for the Goals - emphasises that technology is a cross-cutting theme that underpins the attainment of all other SDGs, including economic development, health and education.

Concluding remarks

As outlined in the preceding sections, boosting connectivity can play an important role in realising Togo's economic potential. Attracting domestic and international investments in internet infrastructure - at all stages of the value chain, ranging from submarine cables to terrestrial fibre networks that bring access to end users - is central to reducing the digital divide within Togo. The development of connectivity infrastructure will also reduce the access gap between Togo and other countries with more mature digital ecosystems.

The digital economy can unlock new pathways for inclusive growth and has the transformative potential to spur innovation, create jobs, improve service delivery and reduce poverty in Togo. The country has already made significant progress in this regard, having put the digital economy at the centre of its medium-term National Development Plan for 2018 to 2022. The finalisation and implementation of the Togo Digital Strategy 2025 will build on recent achievements - such as doubling internet penetration between 2016 and 2020 - and accelerate the country's digital development. Equiano's landing in Lomé in 2022 is expected to contribute to this by boosting internet speeds and broadening access, resulting in faster economic growth and job creation.

TOGO ECONOMIC IMPACT ASSESSMENT: Technical Annex

Table of contents

Introduction and methodology

This study provides technical background to the Togo Economic Impact Assessment, which features an overview of Togo's connectivity ecosystem, the national policy environment, background on Equiano and insights into the role of submarine cables in the global economy. The Togo Economic Impact Assessment highlights the cable's key impacts on connectivity, the economy, and sustainability, which are elaborated upon in the below sections.

This study is based on a theory of change framework that outlines the mechanisms through which the arrival of the Equiano cable will impact Togo's economy. The pathways show the successive impact of Equiano on the supply- and demand-side components of the internet market, the ICT sector, and the economy as a whole. This framework draws on existing literature concerning the impact of subsea cables on the supply and demand for internet broadband, as well as on literature on the impact of broadband on economic performance.

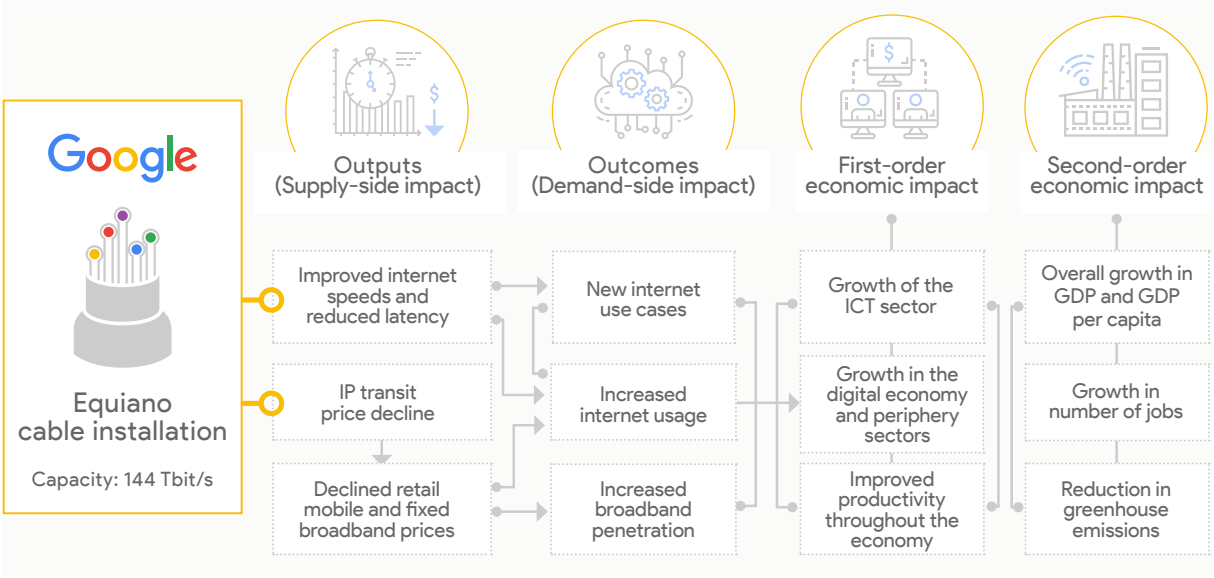
In order to estimate the impact of the Equiano cable on Togo's economy, we establish the relationship between the different variables within the impact pathways. The change coefficients quantifying these relationships are obtained from the results of several studies which have run empirical models with multiple data sets. These studies and their results are outlined in the literature review in the annex. Based on the change coefficients, the change in each variable within the impact pathway framework is then modelled. These calculations serve as the basis for estimating the macroeconomic impacts of the Equiano cable.

Equiano cable assessment

Equiano cable impact pathways

Based on a review of the relevant literature, the Equiano cable is expected to impact Togo's economy through the impact pathways shown in Figure 1 below. Increased bandwidth capacity resulting from the installed cable will have an immediate effect on the supply-side metrics, i.e. the quality, accessibility, and cost of internet in the country.

FIGURE 1 : Equiano's economic impact pathways



Source: Genesis Analytics, 2022

Changes in the supply-side metrics following Equiano's landing are expected to boost demand for, and uptake of, the internet by government, businesses and individuals. In turn, this will contribute to specific sectors benefiting directly from greater internet use, as well as boosting productivity in other sectors of the economy. These sectoral and productivity effects are the first-order economic impacts of the cable. Ultimately, they will lead to higher economic growth, greater job creation and a reduction in greenhouse emissions - the second-order economic impacts. Table 1 below expounds on these impact pathways, which are driven by:

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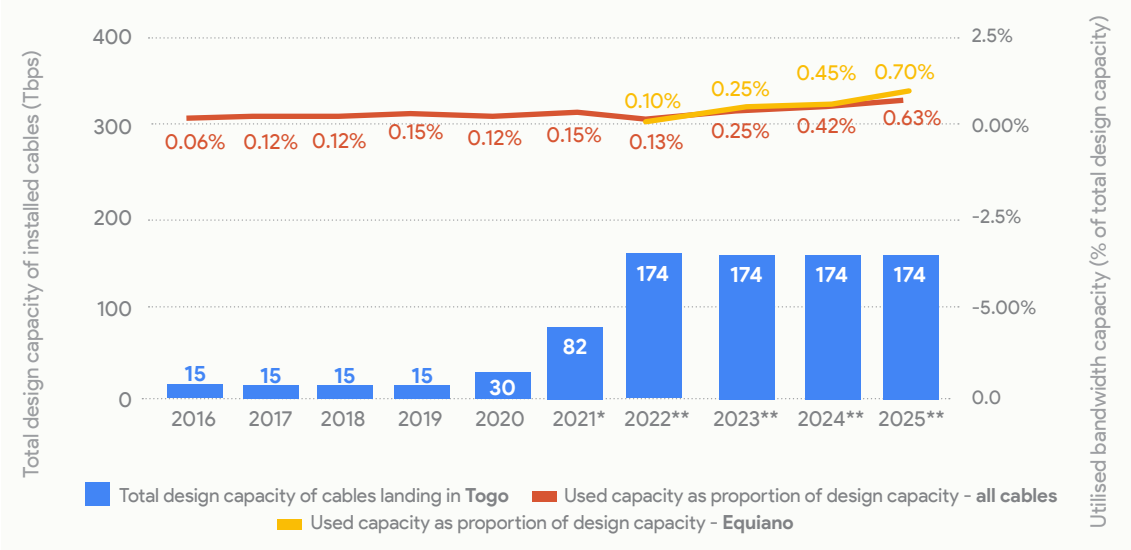
Equiano cable impact analysis

Based on the impact pathways shown in Figure 1, this section presents the results of the Equiano cable impact assessment in Togo, quantifying the changes in terms of connectivity, economic growth, employment and greenhouse gas emissions.

The Equiano cable has a design capacity of 144 Tbps. As with other subsea cables globally, only a portion of this capacity will be utilised and translated into additional international bandwidth capacity for Togo. Although the design capacity of West Africa Cable System (WACS), Togo's only active submarine link as of January 2022, is 30 Tbps, the country's utilised international bandwidth capacity in 2020 stood at 82 Gbps equating to a utilisation of only 0.15% of the design capacity of the cable. Figure 2 below shows that while the ratio of utilised capacity to design capacity has been growing, it has remained below 1%. Equiano's lit capacity is therefore likely to start off very low in order to match the currently low demand for bandwidth relative to the cable's capacity.

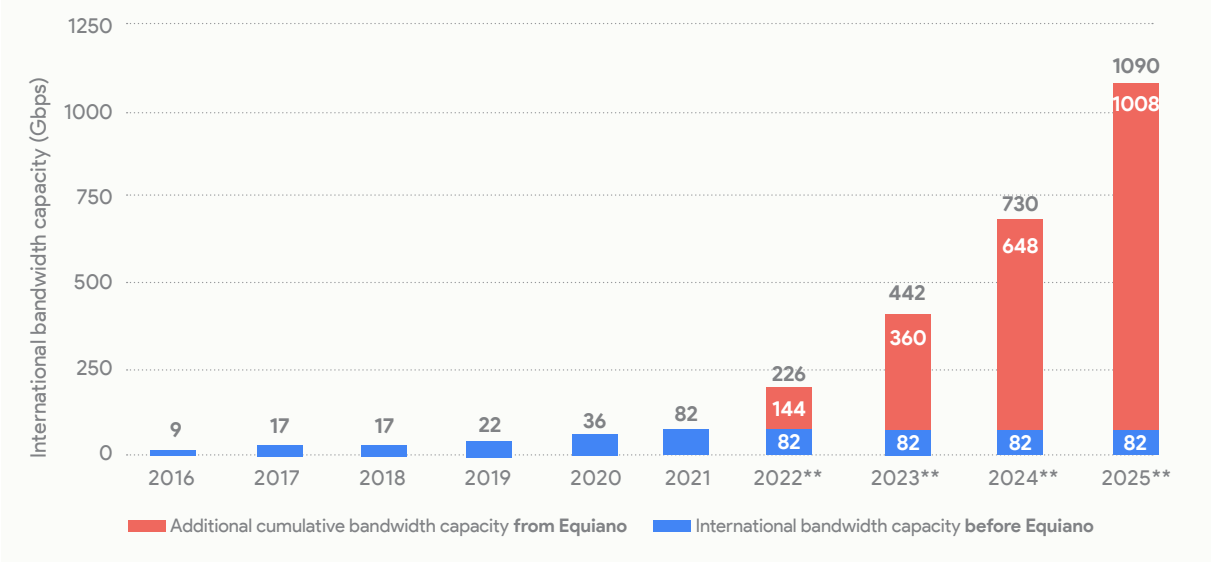
FIGURE 2 : Proportion of used design capacities of cables landing in Togo **2016 - 2025**



Source: Submarine Cable Networks, WACS Overview, 2020 | Genesis Analytics, 2022, team analysis Note: *Forecast | **Equiano impact analysis period | The design capacity of Maroc Telecom West Africa cable is not factored into the forecasted design capacity of cables landing in Togo as its design capacity and ready for service date have not been made public.

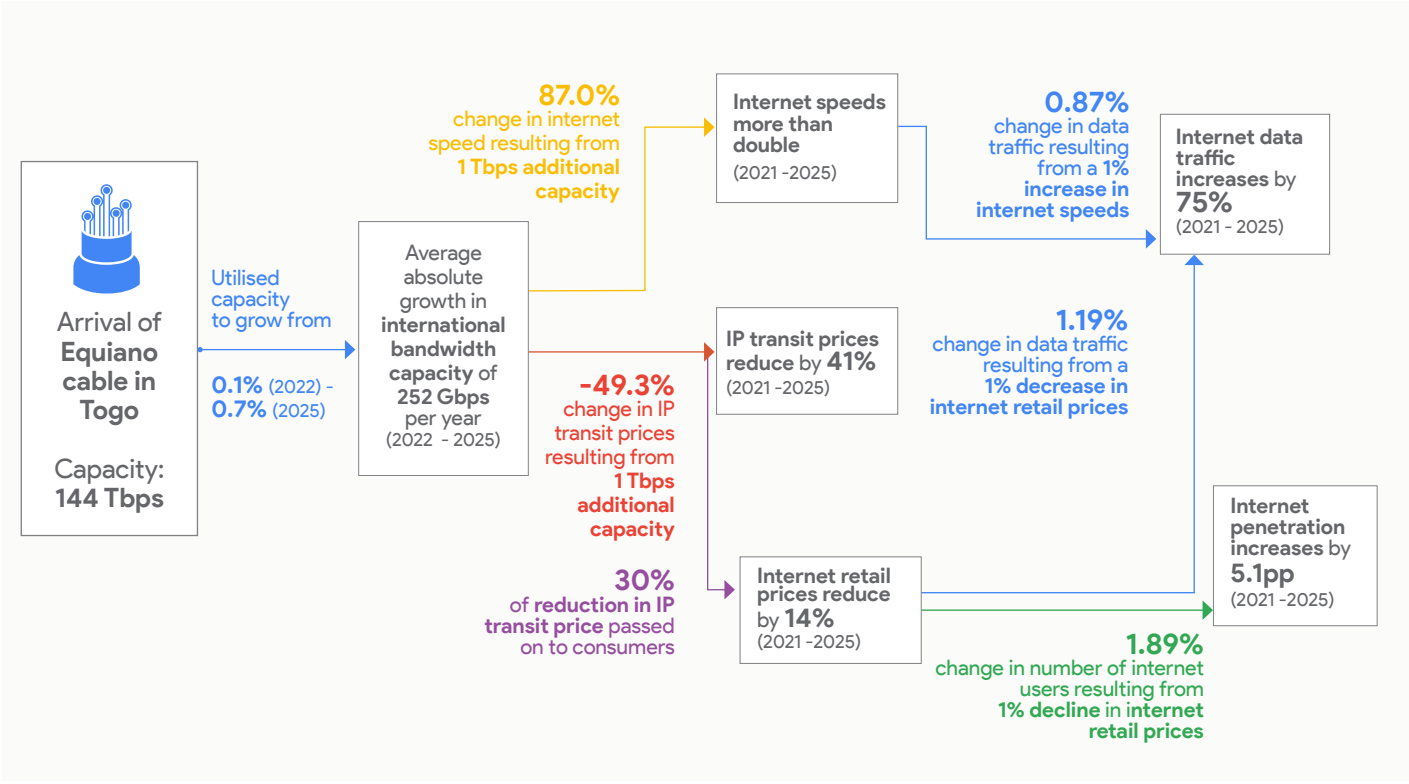
The utilised capacity of the Equiano's branch landing in Togo is therefore modelled to start at 0.1% of potential capacity in 2022. As demand for bandwidth increases, with internet access becoming more reliable and affordable, utilised capacity - relative to the potential capacity - is expected to rise by an average of 0.2 percentage points every year, reaching 0.7% by 2025. This will then translate, one-for-one, into higher international bandwidth capacity for Togo, as shown in Figure 3 below. This increase in bandwidth capacity in turn affects the Togo's internet market's supply-side metrics.

FIGURE 3 : International bandwidth capacity in Togo 2016 - 2025



Sources: TeleGeography, 2021, Global bandwidth services | Genesis Analytics, 2022, team analysis
Note: **Equiano impact analysis period

Overview of the supply-side and demand-side impacts of Equiano



Source: Genesis Analytics, 2022, team analysis. Note: pp - percentage points

Supply-side impacts

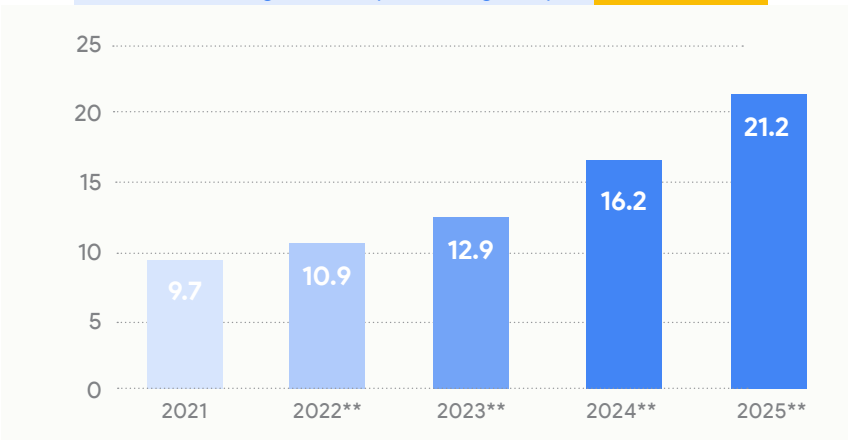
The expanded international bandwidth capacity modelled in the previous section is expected to have an immediate effect on average internet speeds, latency, and IP transit prices. In a 2019 study by Hjort and Poulsen[1] performed across 12 sub-Saharan African markets between 2007 and 2014, average internet speeds increased by 35% after the arrival of a subsea internet cable. Within this period, the subsea internet cables that arrived in the region were ACE, WACS, EASSy and SEACOM, with respective design capacities of 12.8 Tbps, 5.1 Tbps, 4.7 Tbps and 1.5 Tbps. These cables therefore had an average design capacity of 6.0 Tbps. Assuming an average lit capacity of 10% across the cables at the time of installation, the average increase in international bandwidth capacity from the arrival of a subsea cable was 0.6 Tbps.

An average increase of 0.6 Tbps in international bandwidth capacity improved internet speeds by 35% on average. Accordingly, we calculate that an increase of 1 Tbps in international bandwidth capacity would have led to an increase in internet speeds of 58%.

Given Togo's low used international bandwidth capacity[2], we expect the sensitivity of internet speeds to an increase in international bandwidth capacity to be higher than in the Hjort and Poulsen study. We therefore model the impact of an increase in used international bandwidth capacity on internet speeds to be 50% higher. As such, an increment in used international bandwidth capacity of 1 Tbps will result in an 87% increase in internet speeds.

Applying the above coefficient results in internet speeds in Togo more than doubling between 2021 and 2025. Average internet speeds are expected to rise from 10 Mbps in 2021[3] to 21 Mbps in 2025 as a result of Equiano's arrival (see Figure 4).

FIGURE 4 : Average internet speeds in Togo (Mbps) 2021 - 2025



Source: Ookla, 2022, Global Index | Genesis Analytics, 2022, team analysis
Note: **Equiano impact analysis period

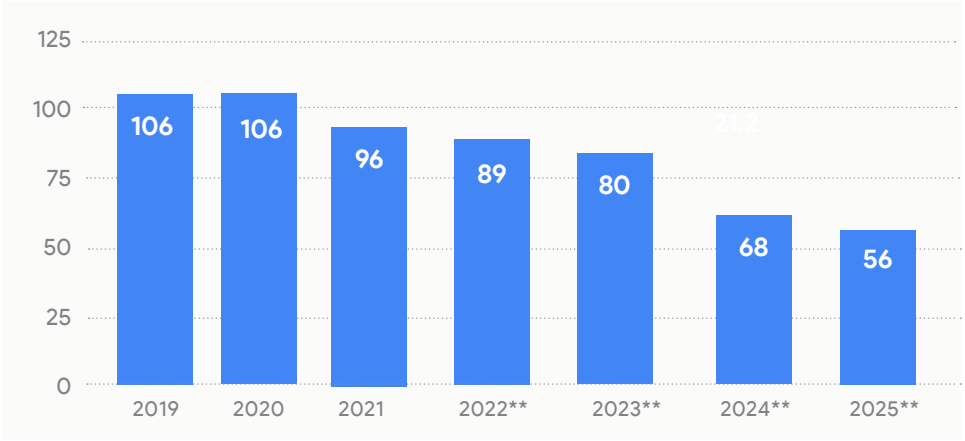
The change in IP transit prices due to increased international bandwidth capacity is derived from the results of a 2020 Analysys Mason study,[4] which quantifies the impact of Google's investment in internet network infrastructure within the Asia-Pacific (APAC) region. The Analysys Mason study finds that as a result of the growth in the network of subsea cables, IP transit prices reduced by 74% between 2010 and 2019 in countries that connected to these cables. The subsea cables Google invested in the APAC region are SJC, Indigo and JGA, which

1. Hjort, J. and Poulsen, J., 2019, The Arrival of Fast Internet and Employment in Africa, American Economic Review.
2. In 2020, the country was ranked 41st out of 52 in Africa. TeleGeography, 2021, Global Bandwidth Research Service
3. Based on median speeds provided by Ookla's Global Index.
4. Analysys Mason, 2020, Economic Impact of Google's APAC Network Infrastructure.

have design capacities of 28 Tbps, 36 Tbps and 36 Tbps respectively. Assuming an average lit capacity of 15% by the end of the period implies an additional bandwidth capacity of 15 Tbps from the three cables. Thus an additional 1 Tbps of international bandwidth capacity results in a decline in IP transit prices of 4.9%.

Since Togo has only one installed submarine cable, once activated, Equiano will provide an alternative submarine route for long-haul transmission of data. Moreover, given the extent to which the additional international bandwidth capacity from Equiano is set to exceed current capacity (see Figure 3), the cable is expected to have a much greater impact on IP transit prices than implied by the Analysys Mason study. This is because the majority of countries included in the study had two or more existing submarine cables, as well as significantly higher international bandwidth capacities than Togo. In 2016, the average used international bandwidth capacity of the 16 countries and territories analysed in the Analysys Mason study was 4,821 Gbps.[5,6] We therefore model an additional 1 Tbps of bandwidth capacity to lead to a 49.3% reduction in IP Transit Prices. **By this coefficient of change, IP transit prices in Togo are expected to fall by 41.4% between 2021 and 2025 as a result of Equiano's landing** (see Figure 5).

FIGURE 5 : Average IP Transit prices in Togo (USD / Mbps / month) 2019 - 2025



Source: TeleGeography, 2021, Pricing Suite | Genesis Analytics, 2022, team analysis
Note: **Equiano impact analysis period

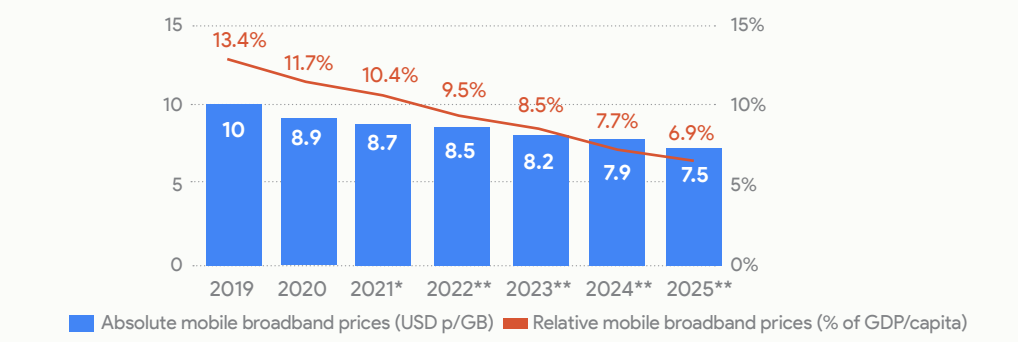
In the absence of sufficient data or extensive literature on the relationship between IP transit prices and internet retail prices, it is assumed that only 30% of the reduction in IP transit prices is passed on to consumers. This figure is based on the assumption that ISPs will seek to increase the capital available to them through retained earnings for the purpose of investing in last-mile infrastructure. Last-mile infrastructure investments are more likely to be made in rural areas, where connectivity is low due to limited infrastructure networks and challenging topographies.[7]

Accordingly, the reduction in internet retail prices year-on-year is 30% of the decline rate of IP transit prices. **Cumulatively, internet retail prices are therefore expected to decline by 14% between 2021 and 2025 as a result of Equiano's landing.**

Figures 6 and 7 illustrate the reduction in average mobile data and fixed broadband retail prices.

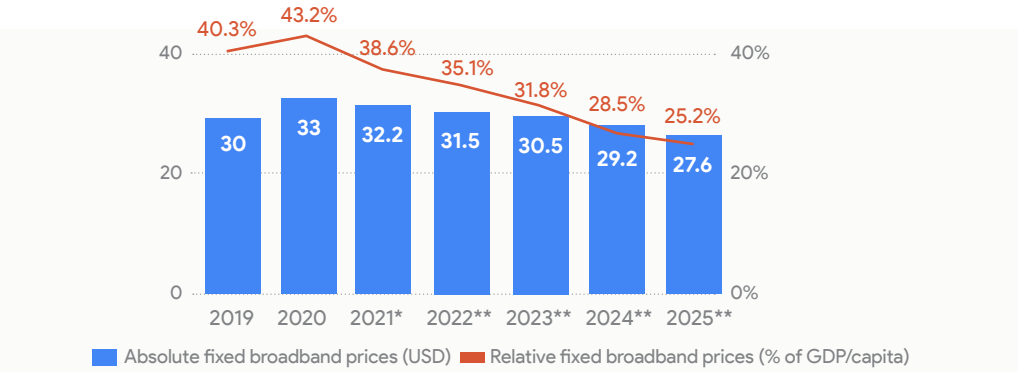
5. TeleGeography, 2021, Global Bandwidth Research Service, Regional Analysis.
6. The countries and territories are: Singapore, Japan, Malaysia, Indonesia, Australia, Taiwan, South Korea, Philippines, Thailand, Pakistan, Vietnam, Sri Lanka, Brunei, Myanmar, New Zealand and Bangladesh.
7. We note that commercial operators have typically been reluctant to invest significantly in unprofitable, remote areas that are characterised by low population density, relative to investing in more urban areas. In this respect, incentives by governments, minimum coverage requirements established by telecommunications regulators and investments by universal service funds play an important part in bringing connectivity to underserved areas.

FIGURE 6 : Average mobile data retail prices 2019 - 2025



Sources: Regulatory Authority for Electronic Communications and the Post (Arcep - Togo), Communications Market Quarterly Review, 2020 - 2017 | IMF, World Economic Outlook, 2021 | Genesis Analytics, 2022, team analysis. Note: *Forecast | **Equiano impact analysis period

FIGURE 7 : Average fixed broadband retail prices 2019 - 2025



Sources: Regulatory Authority for Electronic Communications and the Post (Arcep - Togo), Communications Market Quarterly Review, 2020 - 2017 | IMF, World Economic Outlook, 2021 | Genesis Analytics, 2022, team analysis. Note: *Forecast | **Equiano impact analysis period

Demand-side impacts

As illustrated in Figure 1, Equiano is expected to impact the demand-side of the broadband economy - with faster speeds and cheaper broadband access, consumer demand for connectivity is expected to increase.

Faster speeds (impact pathway 1)

Equiano is expected to improve the speed of connectivity across Togo, leading to better user experiences and a higher demand for data traffic. To establish the extent to which higher internet speeds will lead to a growth in internet data traffic, we refer to the Hjort and Poulsen study.

Hjort and Poulsen found that, as a result of a new subsea internet cable's arrival, the probability that an individual will use the internet daily rises by 8.2%, while the probability of weekly usage rises by 12.3%. To calculate the resultant increase in data traffic as a result of this higher frequency of internet usage, we make two key assumptions. Firstly, all internet users - irrespective of how often they use the internet - have the same average data consumption. Secondly, it is assumed that individuals using the internet weekly make use of it twice a week, on average; while those using the internet less frequently go online once a month, on average.

Calculating the proportional increase in data traffic in the context of the Hjort and Poulsen study further requires data on the frequency of internet use in the countries included in the study - some of which is not available, forcing us to use data from proxies. For this, we apply data on the frequency of internet use in Ghana[8] given the lack of corresponding data in Togo. Ghana is selected as a proxy given it is one of the 12 countries included in the Hjort and Poulsen study. The proportion of daily internet users in Ghana was 43% in 2012, with the remainder using the internet weekly or monthly.[9] We estimate the proportion of weekly and monthly internet users using the corresponding proportion in South Africa.[10] This results in an estimated 42% and 15% of internet users using the internet weekly and monthly, respectively, in 2012. Only 12.7% of the adult population used the internet in Ghana in 2012, indicating that only 5.5% accessed the web daily, 5.3% weekly, and 1.9% monthly.

Hjort and Poulsen found the probability of individuals using the internet daily increases by 8.2% while the probability of weekly usage rises by 12.3% following the installation of a new cable. Applying these results, we find that the installation of a new cable results in 13.6% of adults using the internet daily, 12.3% weekly, and 1.9% monthly. This translates to an increase in data traffic of 244%.

This increase in data traffic, however, arises from both faster internet speeds and lower retail prices, which are both observed in the study. There is no information to infer which pathway contributed more to the increase in data traffic. We therefore assume an evenly split contribution between faster internet speeds and lower internet retail prices. The change in internet data traffic resulting from faster speeds is therefore 122%. However, given that levels of internet penetration in Togo are currently three times higher than they were in Ghana at the time of the Hjort and Poulsen study, we expect that the resultant increase in data traffic due to increased internet speeds will be much lower than in the context of the paper as many users' needs are already connected to existing bandwidth.

Specifically, we model the impact of increased internet speeds on data traffic to be four times lower than it was in the study to compensate for higher internet penetration and speeds. An increase in internet speeds of 35% in the paper results in an increase in data traffic of 31%, implying a change coefficient of 87.4%, - i.e. a 100% increase in internet speeds leads to an increase in data traffic of 87.4%. **Applying this coefficient, data traffic is expected to increase by 100.5% between 2021 and 2025 due to faster internet speeds arising following Equiano's landing in Togo.**

Lower retail prices (impact pathway 2)

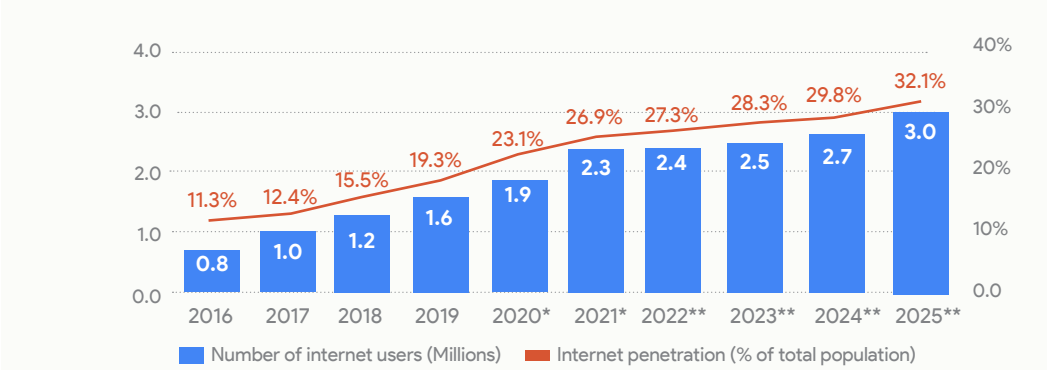
The decline in internet retail prices is expected to drive up both penetration rates and the number of subscribers, while allowing existing users to consume more data and broaden the ways in which they use the internet.

The increase in the number of internet subscribers following a decrease in prices reflects the price elasticity of demand for the internet. An estimate for this can be derived from data on the price elasticity of demand for satellite TV, given the average pricing of satellite TV across different plans and packages is comparable to the average pricing of various internet subscription packages.

8. Togo's neighbour to the west.
9. Nkrumah A., Vaccar C., 2015, Internet Trends and Experience: The Case of Ghana.
10. According to a survey conducted by Statista in 2018, 65% of South Africans used the internet every day while 22% used it at least once a week and 8% went online at least once a month.

A 2012 study by the Commonwealth Telecommunications Organisation[11] charts the number of subscribers of satellite TV as a function of price. From this, we estimate the elasticities at different price points. We take the average elasticity between the USD 70 and USD 40 price points which is -1.89. By this price elasticity, it is expected that the projected overall decline in retail prices of 14.1% between 2021 and 2025 will increase the number of internet users by 31.3%. **This translates to an increase in internet penetration of 5.1 percentage points over the same time frame, as shown in Figure 8 below.**

FIGURE 8 : Number of internet users and internet penetration in Togo 2016 - 2025



Sources: ITU, World Telecommunication/ICT Indicators Database | Genesis Analytics, 2022, team analysis
Note: *Forecast | **Equiano impact analysis period

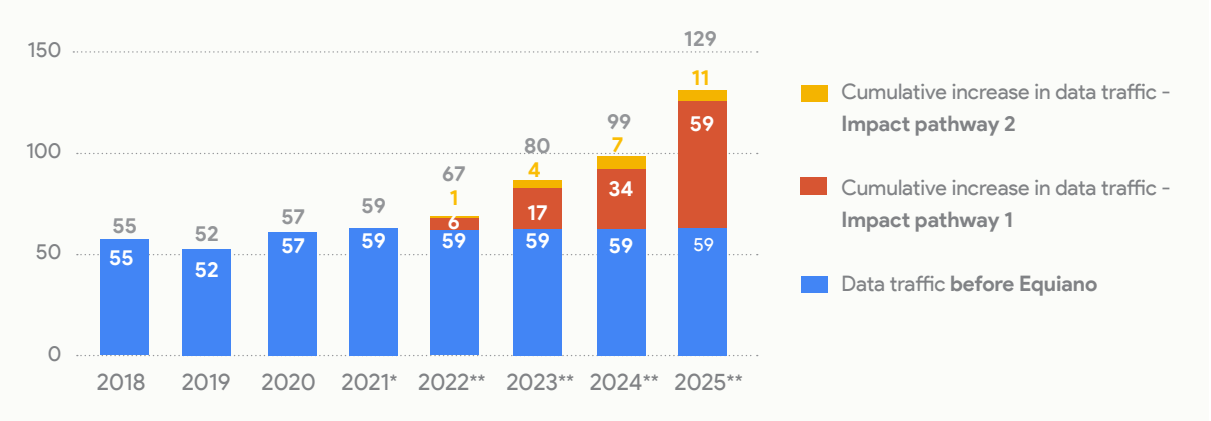
As mentioned in the above section, the total increase in internet data traffic based on Hjort and Poulsen's study is estimated at 244%. Half of this increase is attributable to improved internet speeds, while the other half is attributable to lower internet retail prices. However, as outlined in the previous section, we model the impact of increased internet penetration on data traffic to be four times lower than in the study. This translates to an increase in internet usage of 30.6%, attributable to a 25.7% decline in internet retail prices in the context of the paper, yielding a change coefficient of -118.9%. **By this coefficient, the expected change in data traffic between 2021 and 2025 attributable to lower internet retail prices is 21.5%.**

It is worthwhile to note that the Equiano impact pathway distinguishes increased data traffic caused by intensive internet usage from that caused by extensive internet usage. Greater intensive internet usage arises from existing subscribers using the internet more actively for existing use cases. More extensive internet usage is a result of new subscribers and new internet use cases. Though this distinction exists in the theory of change (Equiano impact pathway), quantifying it credibly is a challenge. The total modelled increase in data traffic of 119.4% between 2021 and 2025 therefore encapsulates both intensive and extensive increases in internet usage.

Figure 9 illustrates the increases in data traffic attributable to the two impact pathways (increased speeds and reduced retail prices) discussed above.

11. Commonwealth Telecommunications Organisation, 2012, The Socio-Economic Impact of Broadband in Sub-Saharan Africa: The Satellite Advantage.

FIGURE 9 : Total data traffic in Togo (PB) 2018 - 2025



Sources: Regulatory Authority for Electronic Communications and the Post (Arcep - Togo), Communications Market Quarterly Review, 2020 - 2017 | Genesis Analytics, 2022, team analysis
Note: *Forecast | **Equiano impact analysis period

First-order economic impact

Examining the first-order economic impact of Equiano[12] is critical to assessing the cable's overall contribution to Togo's economy. The increased data traffic and growing number of internet subscribers will likely boost revenues for ISPs, enabling them to expand as well as invest in improving their fixed and wireless broadband reach. In addition to increasing economic output, this will create a multiplier effect, whereby improved fixed and wireless broadband connectivity spurs a further increase in internet demand, ultimately leading to notable growth in the ICT sector.

Increased adoption of the internet by more people and for more uses will lead to additional growth in the digital economy and peripheral sectors. Although it will cause a shift in business and service delivery models, this will not necessarily entail the demise of traditional businesses. Retailers in countries with large e-commerce industries have reported that some sectors have experienced growth in revenues from their physical stores concurrently with growth in their online sales.

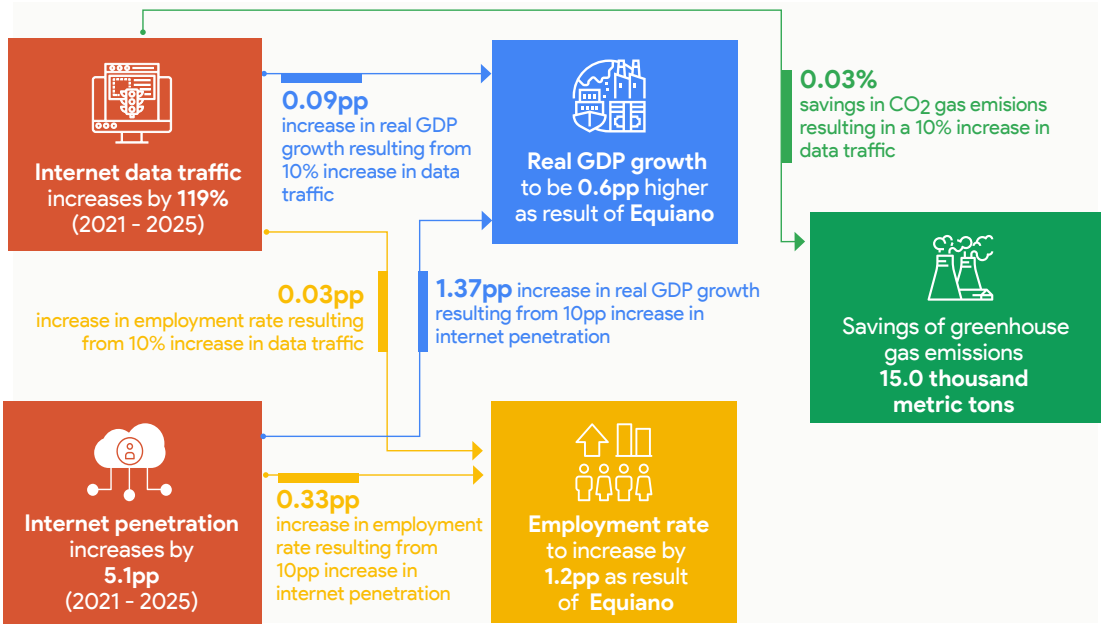
Growth of the digital economy will also spill over into peripheral sectors, such as transport and storage due to the growth of e-commerce. A greater share of business operations being undertaken online will enable improved coordination, collaboration and automation. This in turn will boost the productivity of labour and capital, resulting in greater economic output.

Second-order economic impact

Figure 10 summarises Equiano's second order economic impacts on real GDP growth, employment and savings in greenhouse gas emissions.

12. Though not quantified, the economic growth that should result from the installation of the Equiano cable will manifest primarily through first-order economic impacts. The modelling and quantification of the first-order economic impact requires rich sectoral data, business micro data and data on the digital economy, none of which are readily available. Since the relationship between the outcome variables and the second-order economic impact variables can be established through the results of other empirical studies on this topic, modelling and quantifying the first-order economic impact is not necessary to quantify the ultimate economic impact of the Equiano cable.

FIGURE 10 : Macroeconomic impact of Equiano



Source: Genesis Analytics, 2022, team analysis | Note: pp - percentage points

Real GDP growth

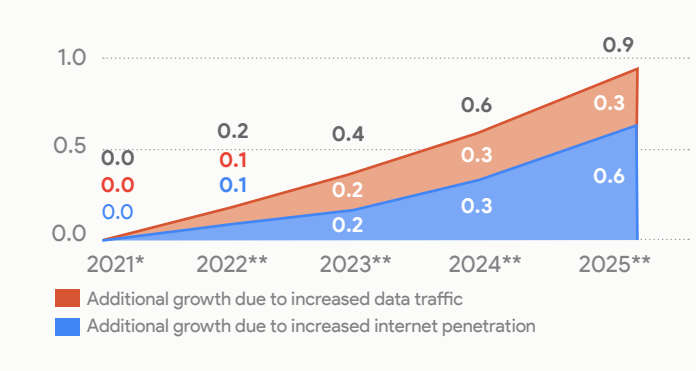
Based on the literature review, increased internet usage and broadband penetration are expected to yield higher real economic growth. A 2020 RTI study[13] found that a 10% increase in international bandwidth consumption per user in South Africa results in a 0.15% increase in GDP per capita.[14] By reconstructing the total international bandwidth consumption (data traffic) in the context of the RTI study (2005-2017) - as well as the resultant increase in GDP based on the observed increase in per capita income - we found a change coefficient of 0.92%. This means a 100% increase in data traffic leads to a 0.92% increase in real GDP, or an increase in the real growth rate of 0.92 percentage points.[15] The resultant increase in average real GDP growth between 2021 and 2025 - due to the 119.4% predicted increase in data traffic by the same year - is thus 0.22 percentage points.

Two separate studies - by Scott[16] and Qiang et al.[17] - found that an increase in broadband penetration of ten percentage points in developing countries leads to a rise in the real economic growth rate, observing increases of 1.35 and 1.38 percentage points respectively. **Taking the average of the two coefficients and applying the result to this model, we find that the increased internet penetration in Togo of 5.1 percentage points between 2021 and 2025 will lead to a rise in average real GDP growth of 0.29 percentage points.**

Accordingly, Togo's real GDP is expected to be USD 193 million more than it otherwise would have been in 2025, reflecting an increase in the average year-on-year real economic growth rate of 0.50 percentage points between 2022 and 2025. The Equiano cable will have led to an additional USD 351 million in total economic output between 2022 and 2025. In the context of an average population growth rate of 2.5%, the additional overall economic growth will result in a higher GDP per capita growth rate of 0.49 percentage points.

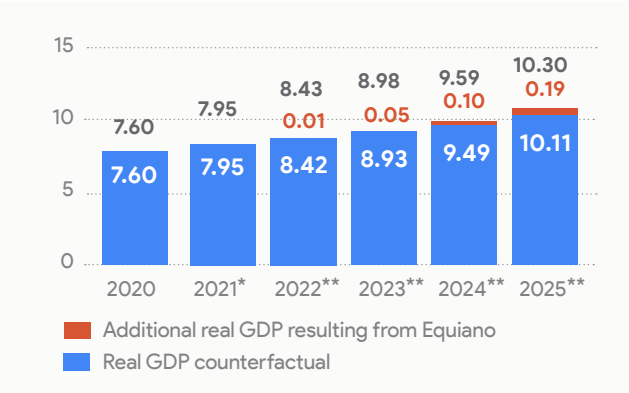
13. RTI International, 2020, Economic Impacts of Submarine Fiber Optic Cables and Broadband Connectivity in South Africa.
14. The RTI series on the economic impacts of submarine fibre optic cables does not cover Togo. The only country covered for which the relationship between international bandwidth consumption per user and GDP per capita is analysed is South Africa, a sub-Saharan African country, hence the application of these results in this RTI report in this economic impact assessment on Togo.
15. At the stage of the analysis, population growth – which impacts GDP per capita – is not yet factored in. It is however incorporated into the modelling, as outlined in the last sentence above Figure 11.
16. Scott C., 2012, Does Broadband Internet Access Actually Spur Economic Growth?
17. Qiang C. et al., 2009, Economic Impacts of Broadband. Information and Communications for Development.

FIGURE 11 : Increase in real GDP growth due to installation of Equiano (percentage points) 2021 - 2025



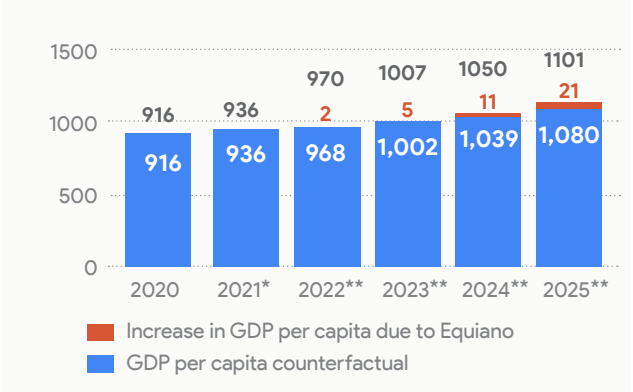
Source: Genesis Analytics, 2022, team analysis
Note: *Forecast | **Equiano impact analysis period

FIGURE 12 : Increase in real GDP due to installation of Equiano (USD billions) 2020 - 2025



Source: IMF, 2021, World Economic Outlook | Genesis Analytics, 2022, team analysis
Note: *Forecast | **Equiano impact analysis period

FIGURE 13 : Increase in real GDP per capita due to installation of Equiano (USD) 2020 - 2025



Source: IMF, 2021, World Economic Outlook | Genesis Analytics, 2022, team analysis
Note: *Forecast | **Equiano impact analysis period

Employment

The increase in data traffic and internet penetration will allow many Togolese to access the digital world for the first time. It will also enable existing users to find new ways of using the internet, leading to greater employment within the digital economy and the ICT sector. To quantify Equiano's impact on the employment rate in Togo, we incorporate the findings of the RTI study on the economic impacts of submarine fibre optic cables and broadband connectivity in Nigeria.[18,19]

The study found that between 2008 and 2013, in areas connected to Nigeria's terrestrial fibre infrastructure (within 500m of a terrestrial fibre optic cable), the arrival of a new submarine cable increased the likelihood of being employed by 7.8%. Between 2008 and 2013, three cables were activated in Nigeria - MainOne, Glo-1 and WACS - with an average design capacity of 7.32 Tbps. Assuming an initial lit capacity of 10% for these cables, and applying the existing change coefficients established in this economic impact assessment so far, we calculate the arrival of a subsea cable in Nigeria translates, on average, into an increase in data traffic of 10.8%, as well as an increase in internet users of 0.9 percentage points. We assume that the increase in data traffic and the increase in the number of internet users contribute equally to the 7.8% rise in the likelihood of being employed in connected areas.

To quantify the number of new jobs created as a result of the arrival of a subsea cable (in the context of the RTI study), we estimate the proportion of the population living in connected areas. In 2013, the metropolitan area network that forms the last-mile fibre optic network covered about 10% of Nigeria by land mass. The metropolitan area fibre optic network was limited to major cities and state capitals like Lagos, Abuja and Port Harcourt. The population of the ten largest cities in 2013 accounted for 15.1% of the total population. It is likely that this is approximately the share of the population that lived within 5km of the last-mile fibre optic network at the time.

Assuming a uniform distribution of individuals within a 5km radius of the terrestrial fibre optic network would mean that 10% of individuals lived within the connected areas i.e. a 500m radius. This means that around 1.5% of Nigerians lived in connected areas over the period covered by the study. As such, the arrival of a subsea cable would have resulted in an increase in the national employment rate of 0.12 percentage points, arising equally from increases in data traffic and internet penetration.

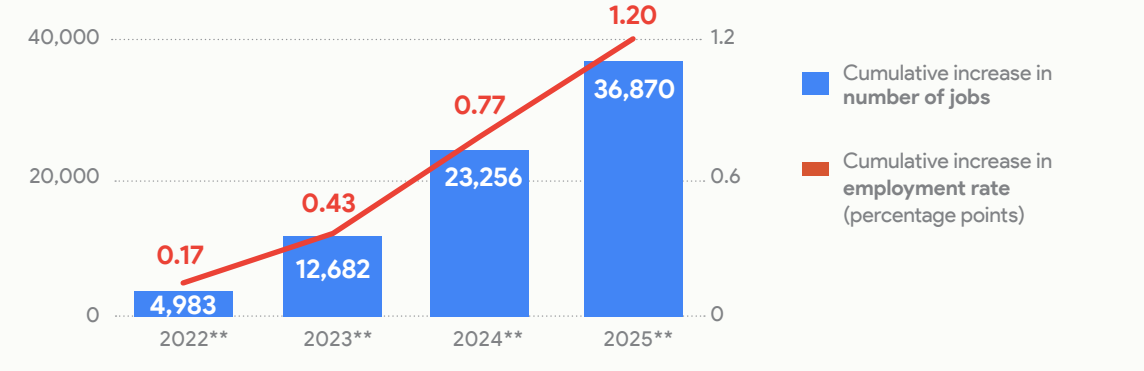
By this metric, a 10% increase in data traffic results in a 0.06 percentage point increase in the national employment rate, while a 10% increase in the number of individuals using the internet leads to a 0.67 percentage point increase in the national employment rate. However, Togo has a more nascent digital economy than in Nigeria. At this early stage of digital development, the pace of digital innovation following an increase in internet speeds and internet consumption in Togo will likely be slower than it would have been in Nigeria. Accordingly, the rate of job creation resulting from increased data traffic and internet penetration will be lower in Togo than in Nigeria. We therefore model the impact of an increase in data traffic and an increase in internet

18. RTI International, 2020, Economic Impacts of Submarine Fiber Optic Cables and Broadband Connectivity in Nigeria.
19. Nigeria is the only West African country covered in RTI International's series of submarine fibre optic cables economic impact analyses. We therefore apply the results from this study as Nigeria has the greatest socio-economic similarities to Togo among the countries covered by RTI International's studies.

penetration on employment in Togo to be half that in Nigeria.[20] Accordingly, a 10% increase in data traffic results in a 0.03 percentage point increase in the national employment rate, while a 10% increase in internet penetration leads to a 0.33 percentage point increase in the national employment rate.

Therefore, the growth in data traffic of 119.4% between 2021 and 2025 is thus expected to increase the employment rate by 0.3 percentage points. Meanwhile, the increase in internet penetration of 5.1 percentage points over the same time frame should result in an increase in the employment rate of 0.9 percentage points by 2025. **The employment rate in Togo should therefore be 1.2 percentage points higher by 2025, representing a cumulative total of approximately 36,870 new jobs created between 2022 and 2025 as a result of Equiano's landing. This equates to an average of 9,200 jobs created annually over this time frame.**

FIGURE 14 : Increase in employment due to Equiano **2022 - 2025**



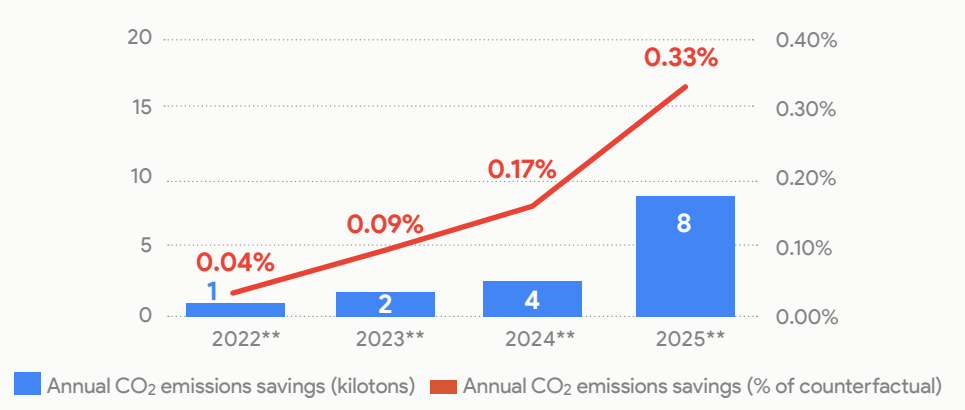
Source: Genesis Analytics, 2022, team analysis
Notes: **Equiano impact analysis period

Greenhouse gas emissions

According to a 2013 SQW study[21] in the UK, an average increase in internet speeds of 48% in 2012 yielded an average saving in CO_2 gas emissions of 0.7 million tonnes. This is equivalent to 0.14% of the counterfactual CO_2 gas emissions for that year. Given that internet speeds only affect data traffic within the framework of this study, the results of the SQW study imply that a 100% increase in data traffic would yield a savings in CO_2 gas emissions equivalent to 0.29% of the counterfactual. **Applying this coefficient to this study, while allowing for an increasing impact of data traffic on CO_2 gas emissions as a result of new internet use cases, yields relatively modest savings in CO_2 emissions of 15 kilotons given Togo's CO_2 emissions -and emissions per capita - are very low.**

20. Togo and Nigeria's respective levels of digital development can be established by comparing internet penetration and the size of the ICT sector in each country. In 2020, penetration stood at 23% in Togo, slightly less than half that in Nigeria (49%). Meanwhile, the ICT sector's contribution to GDP in 2017 was 4.8%, compared with Nigeria's 10.3%. The relative difference in these indicators explains why the impact of the increase in data traffic and employment in Togo is smaller than in Nigeria.
21. SQW, 2013, UK Broadband Impact Study, Impact Report.

FIGURE 15 : Savings in CO_2 gas emissions 2022 - 2025



Sources: Our world in data, Annual CO_2 emissions, 2021 | Genesis Analytics, 2022, team analysis
Notes: **Equiano impact analysis period

Literature review

A number of studies have been conducted analysing the effect that improvements in various elements of internet provision have on the economies of different countries and regions. The following variables have previously been analysed in these studies: the landing of a subsea cable, broadband penetration, broadband consumption, digitisation, and ICT regulation.

Impact of a subsea cable on the internet market and wider economy

RTI analysed the impact of the landing of subsea fibre optic cables and improved broadband connectivity on several sub-Saharan African countries - including South Africa and Nigeria - between 2009 and 2014.[22] The studies focused on the cables that landed during this period - SEACOM, EASSy and WACS. The hypothesis is that the arrival of a subsea cable stimulates network expansion by ISPs, which leads to increased data traffic competition and therefore to decreased internet retail prices, as well as increased speeds. As a result, consumers increase their consumption of digital content, products and services, while some become first-time internet subscribers. The ease of doing business also improves with higher internet speeds, quality and reliability; more businesses use the cloud and e-commerce for the first time. This results in the emergence of new firms and startups, as well as growth in productivity, efficiency and revenue for businesses.

The RTI South Africa study finds that the arrival of the aforementioned subsea cables led to an increase in the employment rate by 2.2 percentage points between 2009 and 2014, though only in areas that are in close proximity to a terrestrial fibre optic cable. At a national level, no impact was observed on employment. Firms in areas that are close to terrestrial fibre optic cables were found to have a 23% increase in net firm entry[23] on a quarterly basis, on account of

22. RTI International, 2020, Economic Impacts of Submarine Fiber Optic Cables and Broadband Connectivity in South Africa. RTI International, 2020, Economic Impacts of Submarine Fiber Optic Cables and Broadband Connectivity in Nigeria.
23. Net firm entry refers to the number of new firms entering a market minus the number of firms closing.

recently installed subsea cables. The arrival of subsea cables is also seen to increase growth in GDP per capita by 1.21 percentage points, leading to per capita income being 6.1% higher after five years as compared to the counterfactual. In the long run, the RTI study finds that increased international bandwidth consumption and broadband penetration have an impact on GDP per capita. A 10% increase in international bandwidth consumption leads to a 0.15% increase in GDP per capita, while a 10% increase in broadband penetration leads to a 0.27% increase in GDP per capita.

The RTI Nigeria[24] study evaluates the impact of the arrival of submarine fibre optic cables on the economy between 2008 and 2013. During this period, there were three subsea cables that landed in Nigeria - Glo-1 (2.5 Tbps), MainOne (5.0 Tbps) and WACS (14.5 Tbps) - with an average design capacity of 7.3 Tbps. The study specifically looks at the impact of the new subsea cables on the likelihood of being employed and the productivity of firms. It finds that in areas with last mile connectivity (within 500m of the terrestrial fibre optic network) the likelihood of employment increases by 7.8%. However, beyond these areas, there was no evidence to suggest the arrival of new subsea cables resulted in job creation. The study also found that firms in connected areas experienced higher productivity and increased input by leveraging improved connectivity. This was especially the case for ICT-intensive sectors such as financial services. This sector was found to have experienced an increase in its exports of 1,100% by 2017 as a result of the arrival of the new subsea cables.

Hjort and Poulsen measured the effect of the arrival of subsea cables on employment and wages in 12 African countries, including South Africa, between 2007 and 2014.[25] They found that employment increases by 2.2 to 3.1 percentage points in areas that are connected (within 500m) to the internet backbone network - the terrestrial fibre optic cable network – in South Africa. The increase in the employment rate in the connected areas does not result from a shift in jobs from the unconnected areas (through migration of employees or businesses) as the impact of the arrival of subsea cables in unconnected areas is near zero and statistically insignificant.

Hjort and Poulsen also found that the increase in overall employment is driven specifically by more employment in skilled occupations. The increase in employment in the connected areas was found to be accompanied by 2.4% to 3.3% increase in average incomes, as proxied by light density at night.

Hjort and Poulsen also identified the mechanism through which the increase in employment is achieved. The arrival of a subsea cable boosts internet speeds and decreases retail prices, which in turn increases internet usage both intensively (greater and more diverse internet usage by existing users) and extensively (the emergence of new users). This leads to the entry of new firms, particularly in sectors that rely heavily on ICT such as finance and services.

Internet speeds in areas connected to the internet backbone were found to have increased by up to 35% after the arrival of a subsea cable. Fixed broadband subscription prices decreased by 25% to 35% annually in the first four years following the installation of a subsea cable, as shown in Figure 16 below. In the connected areas, the probability that an individual uses the internet daily increased by 8.2% to 12.4%, while the probability that an individual uses the internet weekly increased by 12.3% to 14.2% after the landing of a new subsea cable.

24. RTI International, 2020, Economic Impacts of Submarine Fiber Optic Cables and Broadband Connectivity in Nigeria.
25. Hjort J. and Poulsen J., 2019, The Arrival of Fast Internet and Employment in Africa, American Economic Review.

Analysys Mason measured the impact of Google's USD 2 billion investments in network infrastructure - six subsea cables, edge infrastructure and Google Global Cache - in the APAC region between 2010 and 2019.[26] These investments enabled the acceleration of the supply of international bandwidth capacity and increased the diversity of routes, not only benefiting Google's services, but also the broader connectivity ecosystem in the region.

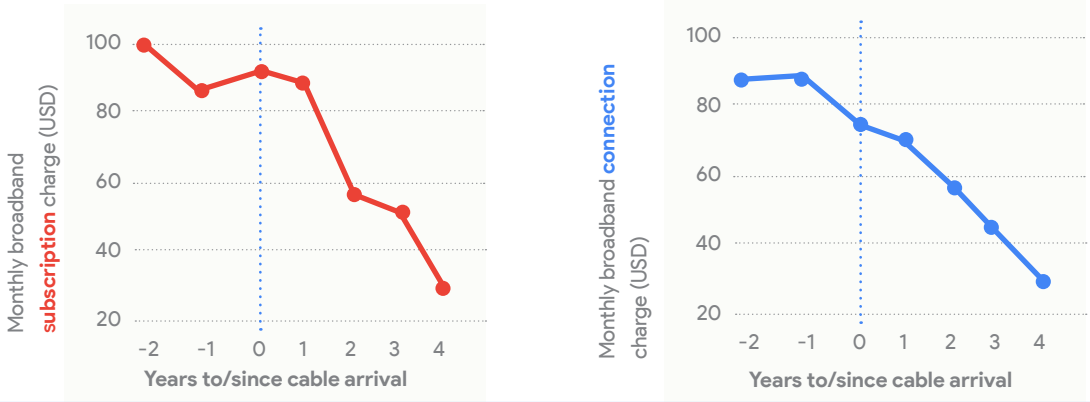
Specifically, 367 Tbps of additional capacity was achieved through the installed submarine cables. This resulted in download speeds four times faster, a 12% to 49% reduction in end-user latency, and a 74% decrease in IP transit prices in the countries that had strong subsea cable connectivity. From this improvement in the connectivity ecosystem, three new internet use cases could be supported - video conferencing, commerce and transactions, and cloud services. Ultimately, between 2010 and 2019, the improvement in the connectivity ecosystem led to the creation of 1.1 million jobs and USD 430 billion in additional GDP within the APAC region.

Impact of increased broadband penetration on economic output

A number of studies have specifically looked at the impact of increased broadband penetration on economic output. In 2016, Minges published an extensive literature review on this subject, outlining the results of various studies that have sought to establish a relationship between these two variables. Katz and Callorda's 2018 study[27] examined the economic contribution of fixed and mobile broadband. Table 2 below shows the results of these studies. All the coefficients were statistically significant with a significance level of at least 10%.

The results from the studies all show a positive relationship between broadband penetration and economic growth, including in emerging economies such as Nigeria. The higher income levels are not only at a national, but also a household and per capita level. Qiang et al.[28] and Scott[29] modelled the impact of an increase in fixed broadband penetration on developing countries' real growth rate. The average between the two authors' findings for this change coefficient is an increase of 1.37 percentage points in real economic growth, following an increase in fixed broadband penetration of ten percentage points. Mobile broadband penetration was found to have a greater economic impact than fixed broadband penetration: a one percentage point increase in the former induced a 0.18% increase in GDP per capita, compared with 0.06% for fixed broadband penetration.

FIGURE 16 : Broadband subscription and connection charges before and after subsea cable arrival[30]



26. Analysys Mason, 2020, Economic Impact of Google's Apac Network Infrastructure.
27. Katz R., Callorda F., 2018, The Economic Contribution of Broadband, Digitization and ICT Regulation. ITU Publications.
28. Qiang C. et al., 2009, Economic Impacts of Broadband. Information and Communications for Development.
29. Scott C., 2012, Does Broadband Internet Access Actually Spur Economic Growth?
30. Hjort J. and Poulsen J., 2019, The Arrival of Fast Internet and Employment in Africa, American Economic Review, pg 1032 - 1079.

Table 2: Impact of broadband penetration on economic output – meta analysis

Author(s)	Focus country(s)/ region	Study time frame	Key explanatory variable	Change in explanatory variable	Dependent variable	Change in dependent variable
Czernich, Falck, Kretschmer and Woessmann (2009)	OECD countries - 25	1996 - 2007	Broadband penetration (% of population)	10 percentage points increase	GDP growth rate	0.65 percentage points
Koutroumpis (2009)	EU countries - 15	2003 - 2006	Broadband penetration (% of population)	10 percentage points increase	GDP growth rate	0.26 - 0.85 percentage points
Zaballos and Lopez-Rivas (2012)	LAC countries - 26	2003 - 2009	Broadband penetration (% of population)	10 percentage points increase	GDP per capita	3.19%
Qiang, Rossotto & Kimura (2009)	Developed countries - 120*	1986 - 2006	Fixed broadband penetration (% of population)	10 percentage points increase	GDP growth rate	1.21 percentage points
Qiang, Rossotto & Kimura (2009)	Developing countries - 120*	1986 - 2006	Fixed broadband penetration (% of population)	10 percentage points increase	GDP growth rate	1.38 percentage points
Scott (2012)	Developed countries - 86*	1980 - 2011	Fixed broadband penetration (% of population)	10 percentage points increase	GDP growth rate	1.19 percentage points
Scott (2012)	Developing countries - 86*	1980 - 2011	Fixed broadband penetration (% of population)	10 percentage points increase	GDP growth rate	1.35 percentage points
Thompson and Garbacz (2011)	Developed countries	2005 - 2009	Fixed broadband penetration (% of households)	10 percentage points increase	GDP per household	0.77 percentage points
Katz and Callorda (2012a)	Panama	2000 - 2010	Fixed broadband penetration (% of households)	10 percentage points increase	Real GDP	0.44%
Katz and Callorda (2018)	Global - 139 countries	2010 - 2017	Fixed broadband penetration (% of population)	1 percentage points increase	GDP per capita	0.08%
Katz and Callorda (2018)	High income countries	2010 - 2017	Fixed broadband penetration (% of population)	1 percentage points increase	GDP per capita	0.14%
Katz and Callorda (2018)	Middle income countries	2010 - 2017	Fixed broadband penetration (% of population)	1 percentage points increase	GDP per capita	0.06%
Thompson and Garbacz (2011)	Developed countries	2005 - 2009	Mobile broadband penetration (% of households)	10 percentage points increase	GDP per household	0.52%
Katz and Callorda (2012b)	Philippines	2000 - 2010	Mobile broadband penetration (% of households)	10 percentage points increase	Real GDP	0.32%
Katz and Callorda (2018)	Global - 139 countries	2010 - 2017	Mobile broadband penetration (% of population)	1 percentage points increase	GDP per capita	0.15%
Katz and Callorda (2018)	Middle income countries	2010 - 2017	Mobile broadband penetration (% of population)	1 percentage points increase	GDP per capita	0.18%
Katz and Callorda (2018)	Low income countries	2010 - 2017	Mobile broadband penetration (% of population)	1 percentage points increase	GDP per capita	0.20%
Czernich, Falck, Kretschmer and Woessmann (2009)	OECD countries - 25	1996 - 2007	Introduction of broadband	-	GDP per capita growth rate	2.7 - 3.9 percentage points
Katz and Callorda (2013)	Ecuador	2009 - 2011	Household having broadband	-	Average annual household income	3.67%
Deloitte (2012)	Global - 96 countries	2008 - 2011	Substitution from 2G to 3G penetration	10 percentage points increase in 3G penetration	GDP per capita growth rate	0.15 percentage points

* Total number of countries included in the study, inclusive of developing and developed countries

Impact of broadband penetration and internet usage on greenhouse gas emissions

The potential of increased broadband penetration and adoption in commercial and social activities to positively contribute to the reduction of greenhouse gas emissions has long been recognised. Several impact pathways lead to this outcome, including: reductions in the use of paper arising from electronic communication and publications; savings in the consumption of petroleum products due to teleconferencing and telecommuting; and reduced energy demand for the construction and maintenance of retail and other commercial real estate spaces due to the proliferation of e-commerce.

In 2007, Fuhr and Pociask[31] estimated the savings in greenhouse gas emissions arising from wide adoption and use of broadband-based applications between 2007 and 2017 in the US. By reviewing scientific literature, they estimated that the potential impact of changes from the delivery of broadband is an incremental reduction in greenhouse gas emissions of more than 1 billion tonnes over the ten-year period. E-commerce would contribute about 21% to the estimated savings in greenhouse gas emissions, teleconferencing 20%, increased electronic publication and communication 7%, while 52% of the savings would be attributable to telecommuting.

In 2013, SQW[32] estimated the environmental impacts of the increase in broadband speeds in the UK, arising from both public and private sector initiatives. Public and private investments in broadband infrastructure are projected to lead to an average increase in broadband speeds across the UK of approximately 48% annually between 2008 and 2025. This in turn is expected to lead to savings of 1.6 million tonnes of CO_2 emissions annually by 2024, and a total of 12.4 million tonnes of CO_2 emissions between 2009 and 2024.

These savings in greenhouse gas emissions are modelled to arise from the following reductions:

- 2.3 billion kms in annual commuting, predominantly in car usage due to increased remote working.
- 5.3 billion kms in annual business travel, largely in car usage, through increased use of video conferencing and online collaboration tools.
- 1 billion kWh of electricity usage per annum through the shifting of server capacity onto more energy-efficient public cloud platforms by broadband-using firms.

Despite this, internet usage and the ICT sector as a whole have their own carbon footprint, resulting from the energy requirements of running data centres, servers, applications and networks.[33] The ICT sector currently contributes 2 to 3% of global greenhouse gas emissions. There has therefore been an effort by various governments, businesses and organisations to mitigate the sector's carbon footprint through new energy-efficient data centres and servers, as well as the increased use of both renewable and carbon-free energy to power internet infrastructure.

31. Fuhr J.P., Pociask S., 2007, Broadband Services: Economic and Environmental Benefits, The American Consumer Institute.
32. SQW, 2013, UK Broadband Impact Study, Impact Report.
33. ITU, Dynamic Coalition on Internet and Climate Change (DCICC), 2009, OECD Conference on ICTs, the Environment and Climate Change.

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