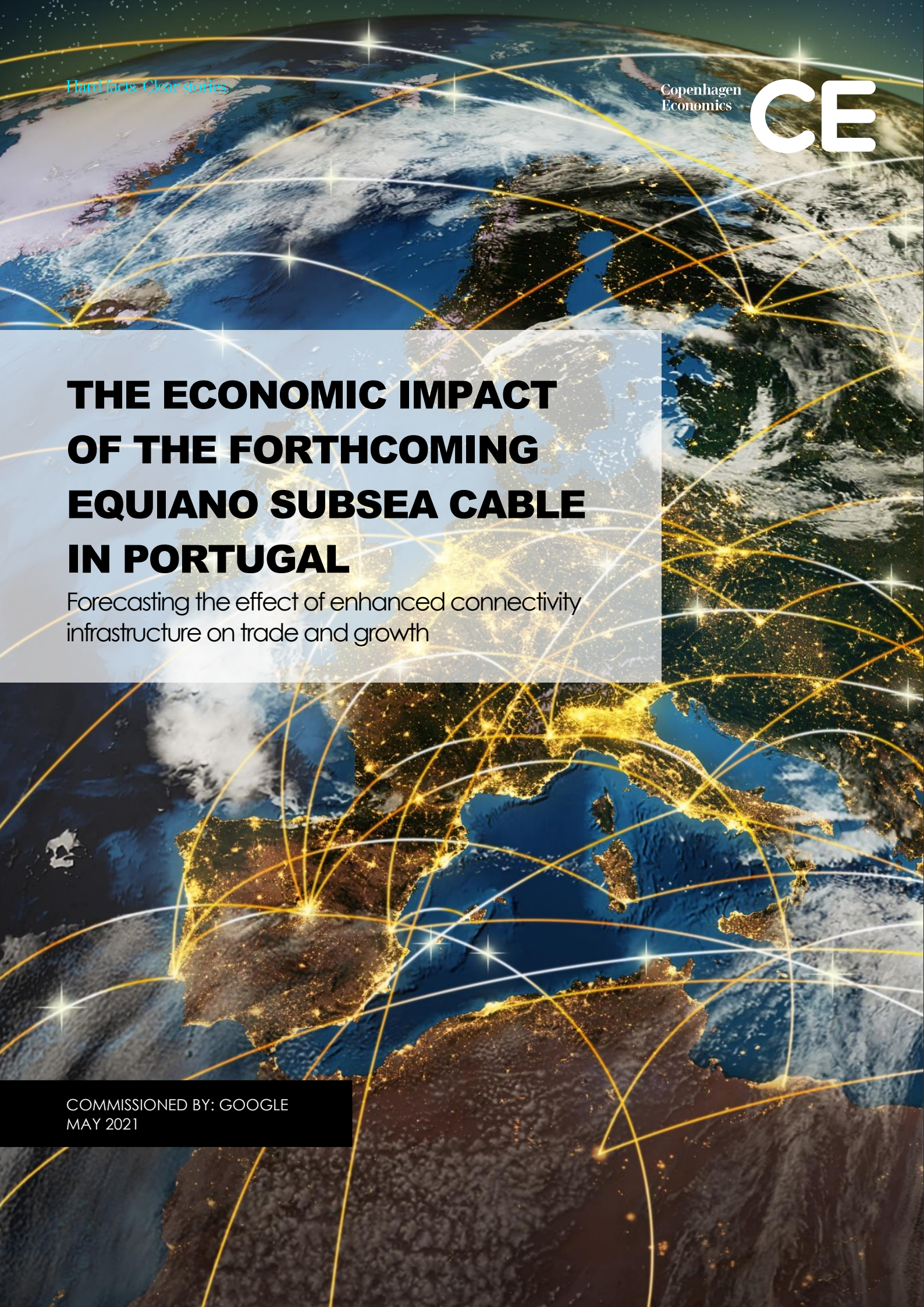

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Copenhagen Economics

THE ECONOMIC IMPACT OF THE FORTHCOMING EQUIANO SUBSEA CABLE IN PORTUGAL

Forecasting the effect of enhanced connectivity infrastructure on trade and growth

COMMISSIONED BY: GOOGLE
MAY 2021

Copenhagen Economics

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Dear Reader,

This research was conducted by Copenhagen Economics for Google in Spring 2021. We analyse the economic impact of the Equiano subsea cable deployed between Portugal and South Africa with branching units along the way. While economic impacts from the cable are to be expected for all countries connected to the cable, this study focuses on the impact on the Portuguese economy.

GOOGLE INVESTS IN THE DEVELOPMENT AND RESILIENCE OF THE INTERNET

Subsea cables are key elements in the global network infrastructure supporting a well-functioning internet. Laid deep on the seabed, they connect islands, countries, regions and continents and power the global growth of the internet, enabling better local user experience and global traffic stability.

Equiano – a Google-funded state-of-the-art subsea cable scheduled to be operational in 2022 – is being deployed from Portugal to South Africa, see below, to improve the digital connectivity between Europe and several West African countries.

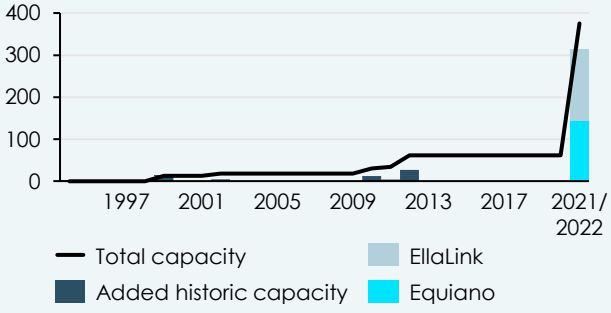
Individuals, companies, the public sector, and telco operators will benefit from Equiano. The users benefit from access to Google's services and broadband provided via telco services operated on some of the cable's fibre-pairs.

Google does not directly provide broadband access, but Equiano enables local partners to provide broadband to a broad set of users.

The premise behind the newest generation of subsea cables, such as the Equiano, is their resilience. These cables can efficiently carry large amounts of traffic. The importance of resilient and adaptable network infrastructures has been evident during the Covid-19 pandemic, where the demand for internet connectivity surged globally.

A key backdrop for Equiano is the wider picture on connectivity in Portugal, which is under development. A key example is EllaLink – connecting Portugal to West Africa and Brazil – which will be deployed in 2021, resulting in a surge of international internet capacity landing in Portugal, see below. The impacts of the two subsea cables are expected to affect the Portuguese economy at the same time. For this reason, considering the connectivity impact of Equiano in isolation, and ignoring the backdrop, would risk painting an overestimated or biased picture of the effect on connectivity in Portugal. Therefore, we first consider the joint effects linked to both subsea cables slated to affect the Portuguese market around 2021/2022. The remainder of the study focuses on Equiano-specific impacts.

Total subsea internet capacity in Portugal and introduction of new capacity (Tbit/s)



The forthcoming new subsea cable connectivity will have a positive impact on the Portuguese economy

We find that the two soon forthcoming cables are expected to lower the latency and increase the internet band-width for internet users in Portugal, which increase the internet usage and subsequently impact Portuguese GDP.

In total, this forthcoming subsea cable connectivity will enable **an increase in Portuguese GDP by up to €500 million per year**. As is the case for the economic contribution of new infrastructural assets, this is a long-term, steady state impact associated with the enhanced economic potential for businesses using this infrastructure (directly or indirectly).

This impact arises from several fundamental economic enablers called transmission channels:

- Trade impacts: Equiano lowers the cost of trading data between Europe and Africa and thus reduces the barrier to trade, allowing more Portuguese firms to trade with Africa.
- Investment impacts: Equiano is expected to have a positive impact on foreign direct investments going to Portugal. Portugal becomes a more attractive investment location as a digital gateway to Africa, including Portuguese-speaking countries.

- Productivity impacts: Key digital infrastructure, such as Equiano, enable and support possibilities for teleworking and online meetings, thereby maximising the time spent working. Companies benefit from reduced cost and time spend commuting and travelling.

- Broader economic impacts: Consumer welfare increase from access to high-quality internet, through which consumers gain access to new online products. In addition, the scalability potential for digital products (e.g., streaming) is enormous, which have positive effects on consumer welfare.

EQUIANO IMPROVES THE DIGITAL CONNECTION TO AFRICA, WHICH IS ESPECIALLY IMPORTANT TO PORTUGAL

Portugal maintains close cultural, economic, and political proximity to several African countries, especially with the Lusofonia countries Angola, Mozambique, and Cape Verde. The Portuguese Government highlights the importance of the EU-African relations under its Presidency of the EU and has also stated that Equiano "reinforces the centrality of Portugal in the relationship of communications with Africa".[1]

Several African countries are important trading and investment partners for Portugal - with 14% of Portuguese goods and services extra-EU exports going to African countries in 2019.

However, in recent years Portuguese exports to Africa have declined. From 2014 to 2019, Portuguese goods and services exports to African countries declined by 36%.

If Portuguese companies take advantage of the benefits from the added connectivity from Equiano, it can help reverse the declining trend for Portuguese trade with Africa. As with any new major infra-structure, a subsea cable delivering significant added capacity such as Equiano can promote trade by reducing transaction costs and capacity constraints for trade with Africa.

1) dinheiro vivo (2019) & República Portuguesa (2019).

GOOD FRAMEWORK CONDITIONS ARE NECESSARY FOR THE DEVELOPMENT OF THE DIGITAL ECONOMY

Portugal has become a hub for subsea cables, not only because of its strategic geographical position as mainland Europe's most South-Western area, but also because of the country's focus to develop and strengthen the digital economy in Portugal.

Portugal has good framework conditions for investments in subsea cables and can continue to invest more in developing its digital economy. With its Digital Plan, Portugal shows the ambition and will to develop its digital economy.

For the continuous development of digital connectivity infrastructure, good framework conditions must be in place to ensure sound investments in digital infrastructure, benefitting citizens, firms, governments, and economic growth. We categorise our recommendations in three groups:

1. Deploying subsea cables

- Continue to have transparent procedures and efficient licensing and permit processes for deploying cables.
- Create a single point of contact for licenses and permits for subsea cables.
- Continue to develop an open environment for foreign investors to finance, own, and manage subsea cables.
- Avoid concentration of landing stations to mitigate risk of multiple outages by ensuring that multiple landing stations sites are available.
- Secure consistent regulation for cable protection zones around cable landing locations.
- Ensure swift procedures to amend existing licences (TUPEM).

2. Maintenance of subsea cables

- Continue to have fast-tracked permit application process for inspection and repair work for quick responses to repair potential damages or problems with the cables.
- Ensure that subsea cable maintenance is exempt from cabotage laws.
- Continue to implement and effectively enforce cable protection laws.

3. General policies and political visions

- Continue to support a vibrant, competitive telecom-munications industry.
- Support high-quality ICT education.
- Safeguard the free flow of data, to enable large and small businesses to tap into the fullest benefits from digital trade.
- Foster greater clarity and reduce mismatches between countries in the tax treatment of subsea cable transactions.
- Support low-income countries in their digital development.

TABLE OF CONTENTS

CHAPTER 1

CONNECTIVITY INVESTMENTS ARE CRUCIAL FOR THE DEVELOPMENT OF THE MODERN INTERNET

In this chapter, we start in section 1.1 by describing how investments in subsea cables are powering the growth of the internet. In section 1.2, we explain the importance of the Equiano cable for the progress of the modern internet. We end the chapter in section 1.3 by explaining why connectivity is important for the resilience of networks.

1.1 SUBSEA CABLES ARE POWERING GROWTH OF THE INTERNET, ENABLING BETTER LOCAL USER EXPERIENCE AND GLOBAL TRAFFIC STABILITY

The demand for better digital connectivity is increasing globally, as the internet is now embedded in the way consumers, businesses, and governments function on a daily basis.

By 2030, the world will consume 20 times more data than it does today, according to some estimates.[1] Businesses are increasingly using cloud services in their digital transformation and many companies find cloud important to their digital transformation strategy.[2] Innovative services such as streaming and digital services in commerce have evolved along with better access networks (4G and fibre optics), and future development in Internet of Things (IoT) will only increase demand for digital connectivity.[3]

However, 40% of the global population is under-connected, or completely without access to the internet, due to reasons such as inadequate coverage and high user costs. By 2030, this figure is expected to decrease to 20%.[4] More users and more data demand per user will require the transmission of increasingly large amounts of data, placing heavy strains on current network infrastructures.[5] Europe is at the forefront of this development with a capacity of 400,000 gigabytes per second, double of the capacity in North America or Asia.[6]

To meet growing demand, investments are made in global network infrastructure, consisting of technologies such as **data centres, edge caches, subsea cables, terrestrial fibres**, resulting in improved reach, speed, and stability, see Figure 1. Companies and consortiums are investing in new, innovative solutions – thereby facilitating the digital transformation for consumers, businesses, and governments around the world.

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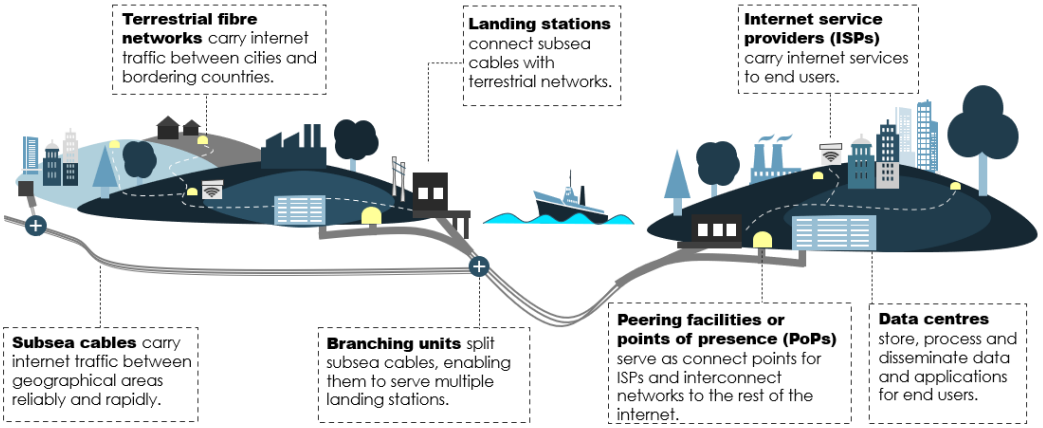
1 McKinsey (2020), p. 3.
2 Analysys Mason (2020). P. 52-53.
3 Analysys Mason (2020). P. 8.
4 McKinsey (2020), p. 6.
5 OECD (2019, a), p. 1.
6 Project Disco (2021), and Global Internet Map 2021.

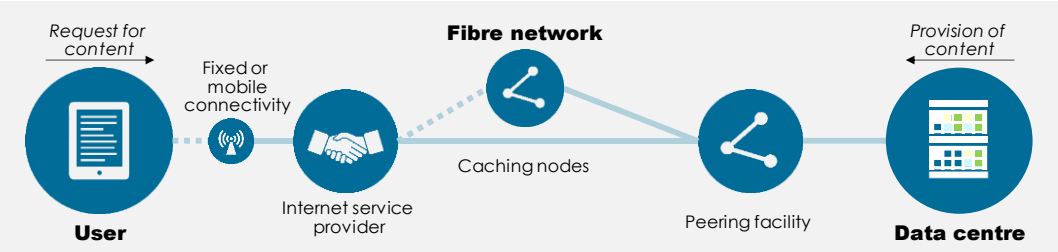
Figure 1
Modern day internet is supported by a complex complementary connectivity infrastructure, which spans continents and oceans to connect users all over the world
Illustration



Source: Copenhagen Economics

Internet users mainly use the internet through *internet access links*, consisting of internet service providers (ISPs), e.g., telecommunications companies that provide fixed broadband services to offices and homes, and mobile service subscriptions, see Figure 2. However, internet infrastructure is supported by a much broader set of essential players.

Figure 2
From data centres to users



Source: Copenhagen Economics (2019) based on Google

Subsea cables are key elements in the global network infrastructure. Laid deep on the seabed, they digitally connect islands, countries, regions and continents and power the global growth of the internet, enabling better local user experience and global traffic stability.

The construction and installation of these cables require large capital-intensive investments that have traditionally been funded by consortiums, including telecom operators or private cable operators, to secure international links.[7] Now, tech companies also invest in and operate major subsea cables globally.[8]

7 Salience Consulting (2015), p.11.
8 See for example: Google Cloud Infrastructure (2020).

Tech companies are investing in securing digital subsea capacity for their own products, while also providing capacity to other users. Therefore, companies such as Google have decided to fund projects and lead the planning, funding, and deployment of subsea cables.[9]

1.1.1 Google invests in network connectivity supporting the growth of online demand

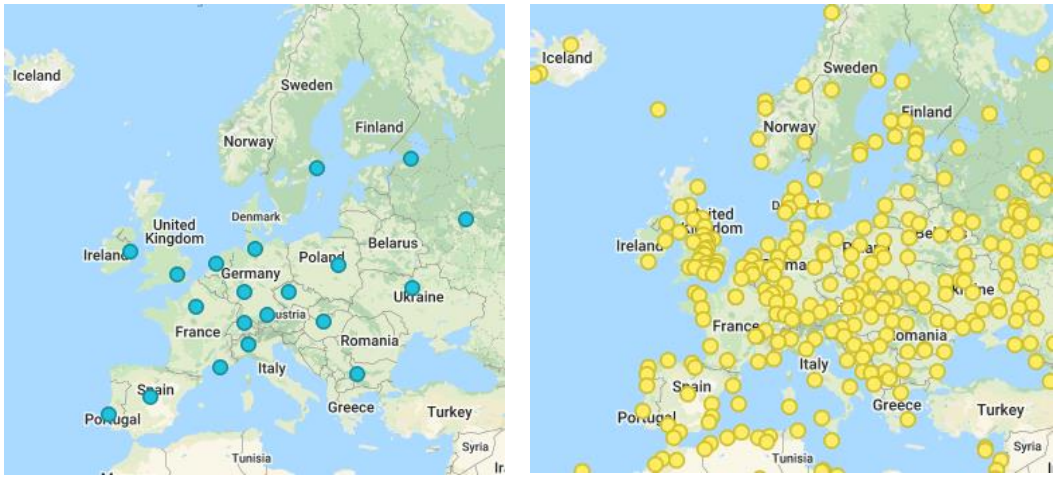
Google is making significant investments into network infrastructure projects around the world including over 15 cable systems in its portfolio worldwide, five of which are in Europe.[10] From 2016-2018, Google invested USD 47 billion in capex projects, including digital infrastructure.[11] Google annually invests millions of euros in fibre networks, subsea cables, servers, caching equipment and routers, and data centres to ensure that end-users are guaranteed a high level of service reliability for Google's online services and cloud solutions.[12]

In addition, Google has invested in an extensive network of Points of Presence (PoPs) and edge nodes, also called Google Global Cache (GGC), which work beyond the peering facilities in the outer edge. GCCs bring data closer to the ISPs and speed up the deployment of some of Google's services and internet content. PoPs deliver content caching machines deployed at Google's network edge.

These networks will become increasingly important to transfer data with the least possible latency for Google and telecommunication providers. Google has invested in several PoPs and many GGC edge nodes in Europe, including in Portugal, see Figure 8.

Figure 3 Maps of Google's facilities in Europe

Points of Presence (PoPs) **Edge nodes (GGC)**



Note: Blue dots are PoPs and the yellow dots are GGC edge nodes.
Source: Screenshots from https://peering.google.com/#/infrastructure, on April 28, 2021

9 Salience Consulting (2015), p.13.
10 Google Cloud Platform and Submarine Networks (2019).
11 Google (2019).
12 Copenhagen Economics (2019).

For an example on how a data journey for Google's content works in practice, see Box 1.

Box 1 Google's Content Delivery Network (CDN)

A typical data journey starts when a user opens a Google app or requests one of its web pages. Google responds to the user's request from an Edge Network location that will provide the lowest latency. Its Edge Network receives the user's request and passes it to the nearest Google data centre. The data centre generates a response that is optimised to provide the best experience for the user at that time. The app or browser retrieves the content required; this can come from multiple Google locations, including its data centres, Edge Points of Presence, and Edge Nodes.

Source: Citation from Copenhagen Economics (2019): Interview with Fionnán Garvey, Global Network Acquisition at Google in July 2019.

1.2 THE EQUIANO CABLE WILL STIMULATE THE PROGRESS OF THE INTERNET AND DATA MARKETS

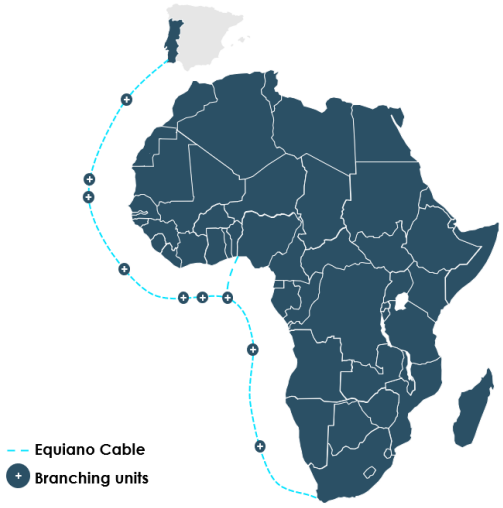
Equiano, a Google-financed subsea cable scheduled to be operational in 2022,[13] is a state-of-the art infrastructure connection based on space-division multiplexing (SDM) technology, which enables very high-capacity networks. It will be the first subsea cable to incorporate optical switching at the fibre-pair level rather than the traditional approach of wavelength-level switching.[14] This greatly simplifies the allocation of cable capacity, giving the flexibility to add and reallocate capacity in different locations as needed.

The cable starts in Portugal, follows the west coast of Africa, and lands in South Africa, with several branching units along the way, see Figure 4. Equiano will improve the digital connectivity between Europe and several West African countries.

[13] Google will wholly fund the upright costs of Equiano.

[14] Google Cloud Infrastructure (2019). https://cloud.google.com/blog/products/infrastructure/introducing-equiano-a-subsea-cable-from-portugal-to-south-africa

Figure 4
The Equiano cable route
Illustrative



Note: The cable has the possibility to connect in more locations from the branching units.
Source: Google Cloud Infrastructure, see https://cloud.google.com/blog/products/infrastructure/introducing-equiano-a-subsea-cable-from-portugal-to-south-africa

Portugal is a strategic location for subsea cables connecting Africa and Europe due to shorter geographical distance between landing points, relative to other European landings, making the overall cable system less expensive.

There are three main cable landing stations in Portugal for existing cables: Sesimbra, Carcavelos, and Seixal. Equiano will land in Sesimbra landing station to optimise diversity and resilience from other subsea cable landings in Carcavelos and Seixal, see Box 2.[15] With a diverse set of cable landing stations, the risk of multiple cable outages decreases, relative to only having one landing station. For example, if all cables landed in the same landing station, a cut under water, e.g., from fishing boats trawling, anchoring or natural disasters, could affect all cables simultaneously. For a description of the authorisation framework for private use of maritime space in Portugal, see Box 3.

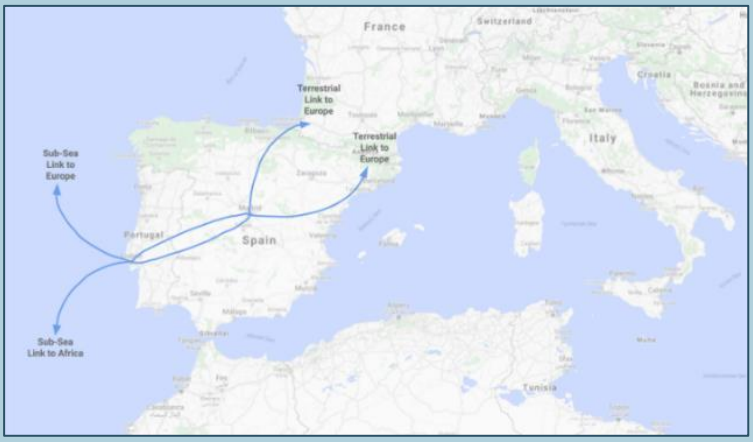
In addition to its connection to Europe, Equiano also supports digital connectivity from Africa to North America through the connections on the Iberian Peninsula, where the Google Grace Hopper subsea cable will connect Spain to North America. Thus, Equiano and Grace Hopper create a digital connectivity "motorway" from West Africa to North America through Europe.[16]

[15] Information provided by Google.
[16] See Google Cloud Infrastructure (2020). These new infrastructures enhance the existing set of cross-Atlantic cables, incl. between Africa and America, see Forum Analytics (2021).

Box 2 Lisbon is a key hub, connecting Portugal to Europe and the world

For a long time, Google has had a critical network presence in Lisbon, Portugal to facilitate key sub-marine connectivity routes between Europe and Africa. This strategic importance only grows with the deployment of Equiano.

Below is a map showing Lisbon's terrestrial links to Europe and subsea connections to bring Equiano's capacity in-land:



Source: Copenhagen Economics (2019), based on interviews with Fionnán Garvey and information from Google.

Box 3 The authorisation framework for private use of maritime space in Portugal

A *Título de Utilização Privativa do Espaço Marítimo Nacional* (TUPEM) is the private use title for maritime space granted by Portuguese Authorities. The TUPEM is not the sole condition for the development of a use or activity in the maritime area, it only allows the holder to use the maritime space for the proposed activities, which should comply with the conditions established in the law for that specific use. The assignment of a TUPEM obliges the holder to effectively use the maritime space and to ensure, at any time, the adoption of the necessary measures to guarantee the good environmental status of the marine environment and the good conditions of coastal and transitional waters, as provided under the Water Framework Directive (WFD) and the Marine Strategy Framework Directive (MSFQ). The combination of the TUPEM with the license to carry out the activity and the fulfilment of all conditions, including environmental ones, results in the conditions for the exercise of the activity.

Under current rules, a TUPEM is granted for a specific use and thus is fixed so that its holder deploying a subsea cable system can only deploy the main cable and any extensions of the main cable that were foreseen in the initial TUPEM. Therefore, any changes to the overall cable system, such as new extensions, require the additional administrative procedure of revising a TUPEM.

Source: Copenhagen Economics, based on Jesus, Almodovar, Simas (2016). Licensing guidance for marine renewable energy projects in Portugal (mainland coastal waters). WavEC Publications, Lisbon

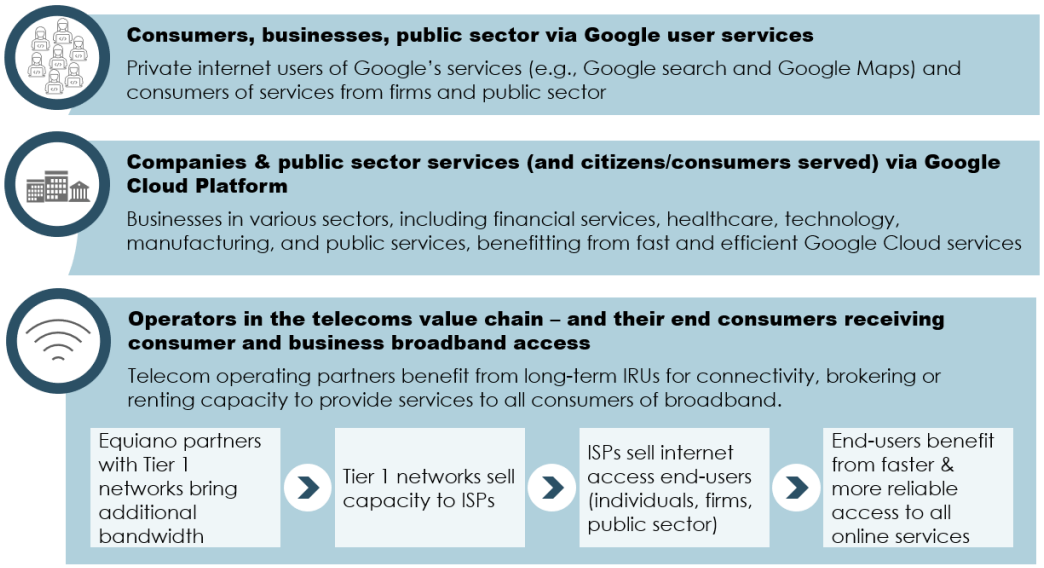
1.2.1 The Google-funded cable is available for a broad set of use for individuals, businesses, and governments

Equiano will consist of 12 fibre-pairs; of these, a portion will be retained by Google for its own private network use, while the remaining fibre pairs will be provided to partners on the cable, e.g., via transferring indefeasible rights of use (IRU) for some of the capacity.[17] Further ways of sharing access to the subsea cables are possible. For example, a cable owner like Google can exchange a portion of the subsea cable capacity with national operators, e.g., in return for the use of the terrestrial backhaul fibre and PoP location facilities managed by telecoms service providers.

Therefore, while Google does not itself provide broadband access, Equiano can support several telecom operating partners who provide high quality, efficient broadband access, benefitting a broad set of end users. The partners will bring their own equipment and operate the acquired IRU cable capacity, providing digital services such as broadband access.

There are three main groups of users that will benefit from Equiano: individuals, companies and public sector, and operators in the telecoms value chain, see Figure 5.

Figure 5
Many types of users benefit from services borne by Equiano



Source: Copenhagen Economics based on Google.

An advantage of this cable setup is that the capacity is available for different types of users with vastly different demand and use, while still meeting Google's own need for increased capacity.

[17] Indefeasible rights of use agreements (IRUs) are common in telecommunications contracts for the supply of cable system capacity services. An IRU is a permanent contractual agreement, e.g., between the owners of a cable and a customer of that cable system. Customers may alternatively buy capacity via leasing. In the case of an IRU, the customer purchases the right to use a specified capacity amount for a specified number of years. Customers who purchase IRUs can also then lease the capacity to other companies.

Equiano not only delivers benefits to those users using Google services, but also for other services that rely on the flow of information and data over the same connectivity infrastructure, see Figure 5.

Another way to consider why companies like Google invest in new large-scale infrastructures like Equiano is via the economic concept of vertical integration. Vertical integration can drive economic efficiencies across the value chain through greater quality, reduction of transaction costs, tapping into synergies, and utilizing inherent capabilities in the company, see Box 4.[18] For the same reasons, a Google-funded cable such as Equiano can be considered a positive example of an investment and risk-taking initiative delivering wider economic benefits via vertical integration.

Box 4 Vertical integration: turning challenges into opportunities

Some companies choose to invest in their supply chain, for example to supply infrastructure to and secure access for their products or to reduce the inefficiencies from imperfect contracts in their supply chain.

While there are challenges to vertical integration, certain efficiencies may arise. Efficiencies from vertical integration strategies include:

1. Vertical integration allows companies to ensure quality standards in their product delivery to customers, as companies take control of the value chain.
2. Vertical integration mitigates frictions (e.g., transaction costs) between the steps of the value chain.
3. Vertical integration produces synergies through the value chain, resulting in a reduction of redundant processes.
4. Vertical integration utilizes company-specific capabilities, such as company culture, skills, or routines, which cannot easily be transferred between a company and its supplier.

Source: CE team review of economic literature, see e.g., Joskow, (2006), OECD (2019), and Lafontaine & Slade (2007)

Almost at the same time as Equiano is being deployed, so is the new cable **EllaLink** starting in Portugal, connecting via West Africa across the Atlantic Ocean to Brazil.[19] The characteristics of Equiano and EllaLink are shown in Table 1. Both cables are a significant contribution and a major step-change over the existing stock of connectivity.

[18] There are many positive examples of vertical integration in the tech sector leading to broader economic impact on the economy. See for example Copenhagen Economics (2020)

[19] EllaLink has 7 focal points landing in Portugal, 4 focal points in Brazil, 2 in Morocco, and 1 in Madeira.

Table 1
Characteristics of Equiano and EllaLink

Cable	Equiano	EllaLink
Expected deployment year	2021/2022	2021/2022
Landings	Portugal (Sesimbra), Nigeria, South Africa, and other branching units along the route	Portugal (Sines), Brazil, Morocco, and Madeira
Capacity	144 Tbit/s	170 Tbit/s (up to 100 Tb/s intercontinental connectivity trunk between Portugal and Brazil; separately, capacity in a domestic link to Madeira and a cross-country link to Morocco)

Source: Google, Forum Analytics (2021), Submarine Networks (2019), EllaLink (2021) press release, and information provided via email by Philippe Dumont, CEO EllaLink, May 2021.

1.3 BETTER CONNECTIVITY IMPROVES THE RESILIENCE OF NETWORKS

Connectivity infrastructures are not spared from potential risks of disruptions caused by unexpected events, such as natural disasters. However, there are certain actions capacity providers, such as Google, can take to ensure maximum resilience against unforeseen events.

The premise behind subsea cables, and especially the newest generation of subsea cables, is that they are able to carry large amounts of traffic efficiently and reliably. Subsea cables have evolved enormously and there are continuous improvements to increase capacity, reduce physical size, and increase reliability of components.[20] The newest generation of fibre-optic subsea cables is capable of transmitting over two hundred terabits of data per second, compared to a few megabits per second through satellite services.[21]

Moreover, data can be transmitted and rerouted over multiple subsea cable paths, which is particularly important in the case of cable disruptions. Though subsea cables are laid deep on the seabed and therefore are not exposed to much traffic and other external aggressors, subsea cables have experienced both damages, caused by fishing and shipping activities and natural disasters such as earthquakes and tsunamis. Thanks to cable repair ships at strategically placed facilities around the world, cable repair operations are typically deployed quickly.

In addition, cables and cable landing stations are being increasingly strategically placed on safer routes and away from busy ports and fishing areas.[22] Multiple cable landings in different areas on the coast also lower the risk for multiple subsea cable outages.[23]

As the Covid-19 pandemic has shown, there is a need for connectivity infrastructures to be adaptable and resilient to changing conditions and evolving internet demands, so internet users can continue to operate at global scale with minimal inconveniences. In the pandemic, we saw the resilience of the digital infrastructure when there was a sudden surge in demand for digital services as offices

[20] Carter et al. (2009)
[21] Google Cloud Infrastructure (2021) and Sea Power Centre – Australia (2012).
[22] Carter et al. (2009)
[23] For example, Bangladesh had a total loss of network transmission for at least one week in 2007 due to sabotage on their main cable. Harvard Kennedy School (2010), p. 38.

shifted to workers' homes, demand for video streaming rose, and shopping online became the norm.[24] The existing connectivity infrastructure passed this test, but continuous investment and development in infrastructure is needed to ensure a resilient internet in the future to serve the increasing demand for digital services.

Resilience is a core objective of Google's service offerings, and it is ingrained in Google's three key principles for design, architecture, and operations to avoid cable disruptions.[25] Namely, Google strives for resilience by:

i) designing hardware and software that is strictly proprietary and purpose-built to ensure minimum latency and maximum performance,
ii) proactively identifying dependencies and eliminating single end points of failure and vulnerability across their globally distributed systems,
iii) automating configurations, infrastructure, and services through an audited software development lifecycle and management process in order to eliminate toil, manual effort, and errors.

[24] Hillman (2021), p. 1
[25] Google (2020), p. 2

CHAPTER 2

IMPROVED DIGITAL CONNECTIVITY HAS POSITIVE ECONOMIC IMPLICATIONS

In this chapter, we start in section 2.1 by explaining how investments in the new subsea cables benefit African and European economies. In section 2.2, we explain how subsea cables increase internet usage, and in section 2.3, we find the 2021/2022 forthcoming cables' impact on GDP in Portugal based on estimates found in the literature, see Box 5.

Box 5 We estimate the combined impacts from the forthcoming cables to Portugal in 2021/2022 (Equiano and EllaLink) due to simultaneity of the economic effects

A key backdrop for Equiano is the wider picture on connectivity in Portugal, which is under development. A key example is EllaLink – connecting Portugal to West Africa and Brazil – which will also be deployed in 2021, resulting in a surge of international internet capacity landing in Portugal. The impacts of the two subsea cables are expected to affect the Portuguese economy at the same time. For this reason, considering the connectivity impact of Equiano in isolation, and ignoring the backdrop, would risk painting an overestimated or biased picture of the effect on connectivity in Portugal. Therefore, we first consider the joint effects linked to both subsea cables slated to affect the Portuguese market around 2021/2022.

In the following chapters, we zoom in specifically on *Equiano's* role as an enabler of trade with Africa and related economic developments.

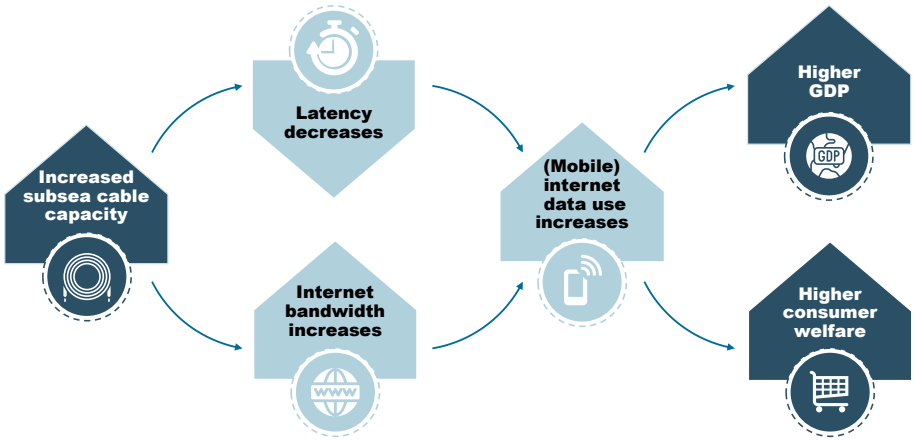
2.1 THE NEW SUBSEA CABLES BENEFIT THE ECONOMIES IN AFRICA AND EUROPE

Investments in subsea cables, such as the 2021/2022 forthcoming cables Equiano and EllaLink in Portugal, improve the connectivity between different parts of the world, and internet users benefit from higher internet bandwidth, lower latency,[26] and increased stability, see Figure 6. The improved connectivity lowers the costs of using the internet for consumers, businesses, and governments, which increases the demand for the internet.[27] Internet usage is associated with higher GDP and consumer welfare.

[26] Internet bandwidth is the maximum rate of transferring data through a cable, and latency is the time it takes for data to be transferred from its source to its destination.

[27] This is also in line with economic theory: When prices decrease, the demand increases, *all things equal*.

Figure 6 Subsea cables' impact channels



Source: Copenhagen Economics based on literature review.

2.1.1 Benefits to Europe

The data economy is expected to grow significantly, and some estimates indicate that the data economy will account for 6.3% of EU GDP by 2025.[28] Europe needs to keep pace with infrastructure investments to avoid losing market shares.

Europe's historically pre-eminent position in subsea cable infrastructures is at risk due to ageing technology and is therefore in need of investments. High quality connectivity between EU member states to the rest of the world is essential to ensure that European businesses have access to the cost effective low-latency connectivity, leading to new opportunities in data exchange and data hosting.

In high-income European countries, such as Portugal, the impact on GDP of a single *additional* subsea cable is *less profound* than in countries which are not as digitally connected.[29] For low-and lower-middle-income countries, such as Nigeria, the *additional* impact is relatively larger, as Nigeria is less digitally connected than Portugal, and thereby the relative change is larger.

With that being said, connecting Europe to Africa and South America, in the cases of the forthcoming cables, still yields important economic benefits for Europe. There is a big difference between strengthening the connectivity internally in Portugal or connecting Portugal to Spain, relative to connecting Europe to whole other continents such as Africa or South America. The new subsea cables are expected to bring significant economic gains to European countries, as an increasing share of the world's future economic growth is expected to originate from Africa.[30]

Even though the forthcoming cables only land in Portuguese coastal areas, the cables are important for the connectivity in the whole of Europe. Interior regions of Portugal and other European countries, including land-locked countries, are connected through terrestrial cables to the global internet via networks relying on subsea cables such as the forthcoming cables.

[28] Vodafone (2021), p.3.

[29] This means that the *additional* connectivity of the new cables is relatively small compared to countries with less existing connectivity. For example, there are already 10 subsea cables connected to Portugal. However, Equiano and EllaLink will increase the total connectivity in Tbit/s. See SFT (2018).

[30] See for example World Economic Forum (2020).

2.1.2 Benefits to Africa

The internet is global, but it is not equally well distributed across the world. Africa is the continent that stands to gain the most from improved digital connectivity, as it is the least digitally connected populated continent in the world.

The internet penetration rate in Africa is substantially lower than that observed in the rest of the world.[31] In 2020, 39% of the African population had access to the internet, compared to 63% in the rest of the world.[32] This gap is even more substantial for Sub-Saharan Africa, where the internet penetration was 26% in 2019.[33] Furthermore, the African continent has the *least affordable internet prices* in the world.[34] Improved connectivity and lower user costs for broadband would enable more people in Africa to participate in the digital economy, improving conditions for growth on the continent.

Africa's digital growth potential is enormous as the continent is home to 17 percent of the world's population, but only has one percent of its data centre capacity. Between 2015 and 2019, Africa's international bandwidth grew by 45 percent annually.[35]

In addition, some African countries are excelling quickly in ICT infrastructures, especially in the banking sector. For example, 96% of African banks regard digital transformation as one of the most important factors in their bank's growth strategy.[36]

This digital transformation, including the adoption of systems to digital based banking and payments, are heavily dependent on ICT infrastructure such as cables, therefore increasing the need for digital connectivity to expand these industries.

With Africa, and especially Sub-Saharan Africa, lagging behind in internet penetration rates, Equiano is expected to facilitate inclusive digital transformation by bringing significant connectivity improvements to the population, business and governments in several African countries that are currently under-connected.[37]

In the rest of this chapter, we focus on the economic impact for Portugal, but Portugal is not the only beneficiary of the forthcoming cables. Other European countries and some South American and African countries are also expected to gain economic benefits of the cables.

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31 The internet penetration rate is defined as the share of population with access to the internet.

32 Source: Internet World Stats.

33 GSMA (2020), p. 1.

34 The Borgen Project (2020).

35 Hillman (2021), p.17.

36 Backbase (2020).

37 Note that mainland Africa is still relatively poorly connected by fibre-optic cables, where many less populated regions (e.g., those with less than 10 people per square kilometre) lack terrestrial connections altogether or are served by old copper and coaxial cables. In other words, new submarine cables will not fix all of the barriers to connectivity in Africa, especially for populations living inland. For such a large continent, improving the terrestrial fibre optic network is expensive, which is a major factor holding back digital development in-land. See Ngari & Petrack (2020) & empower africa (2021).

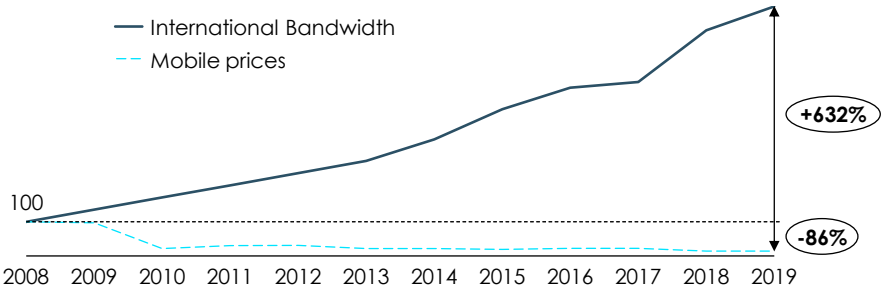
2.2 SUBSEA CABLES ENABLE AND STIMULATE HIGHER INTERNET USAGE IN PORTUGAL

The forthcoming cables will **increase internet usage** in Portugal when the cables are established, and businesses and consumers start using the added capacity.[38] Subsea cables improve the quality of the internet in terms of higher bandwidth and reduced latency, which increases the demand for internet data use.[39]

In APAC countries, Google's subsea cables are found to **increase the internet bandwidth** and **reduce the latency** of the internet.[40] In addition, APAC countries that are well-connected by subsea cables are found to have 74% lower prices than less connected APAC countries.[41]

Portugal is already well-connected with the world through several subsea and terrestrial cables and has experienced decreasing prices and increasing international internet bandwidth in recent years. From 2008 to 2019, mobile subscription prices fell 86% and international bandwidth grew 632%, see Figure 7.

Figure 7
Mobile subscription price and international bandwidth development in Portugal, 2008-2019
Index, 2008 = 100

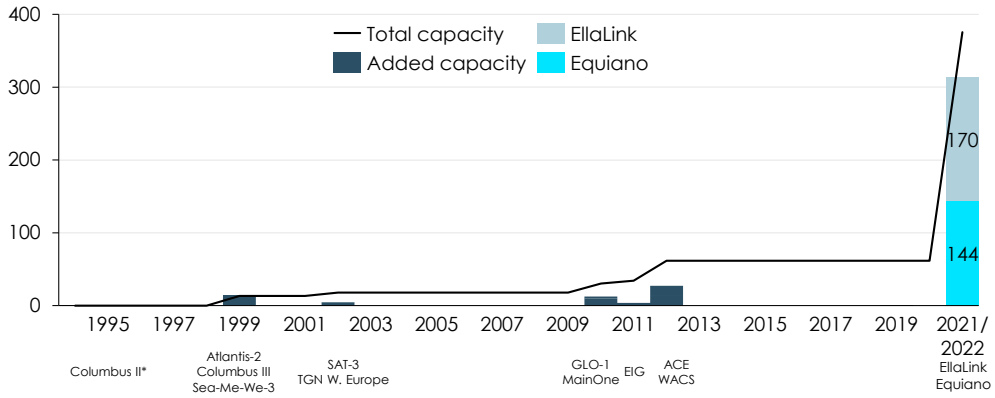


Note: International bandwidth is the total used capacity in Mbit/s. Numbers for international bandwidth are missing for 2008-2012 and a linear development is assumed. Mobile prices cover "mobile cellular low usage" in USD. International bandwidth is not the only driver of mobile subscription prices.
Source: Copenhagen Economics based on ITU

The two forthcoming cables both have larger terabit/s capacity than the total existing subsea cable capacity, see Figure 8, enabling future increased demand for data transfers and improving the resiliency of the internet. Capacity across multiple cables allows subsea cable operators to swap capacity to other routes or cables for a more optimal allocation of the bandwidth, thereby ensuring that the pressure on individual cables does not exceed their capacity limits.[42] This further drive down costs of international bandwidth, leading to increased internet usage.

38 See the appendix and Analysys Mason (2020).
39 Analysys Mason (2020), p. A-8.
40 Analysys Mason (2020), p. A-4 to A-6.
41 Analysys Mason (2020), p. 36-37.
42 Analysys Mason (2020). P. 36-37.

Figure 8
Timeline of new subsea cables and total capacity landing in Portugal, 1994-2022
Tbit/s

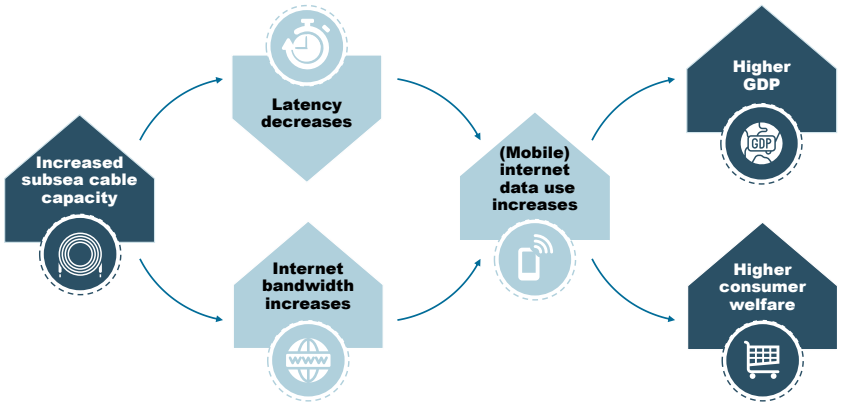


Note: *Columbus II only lands on the Azores, not on Portugal mainland. Furthermore, Columbus II was planned to be taken out of service in 2019.
Source: Copenhagen Economics based on Forum Analytics (2021): *Submarine Cable Almanac, issue 37*

2.3 INCREASED INTERNET CAPACITY LEADS TO HIGHER GDP IN PORTUGAL

We have established that subsea cables increase internet usage, and we now identify a positive link between internet usage and a country's macroeconomic performance, the right part of Figure 9. This is an important finding, and it follows the traditional economic relationship between infrastructure and economic growth: Subsea cables generate socio-economic value to society as any other infrastructure investment.

Figure 9 Subsea cables' impact channels

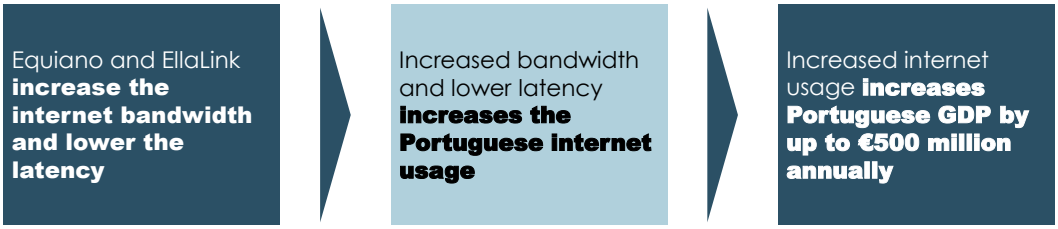


Source: Copenhagen Economics based on literature review.

We estimate the potential impact to be up to **€500 million higher GDP per year** in Portugal associated with improved digital infrastructure from the forthcoming cables being deployed in 2021/2022, see Figure 10.[43] This is a *long-term and recurrent impact*, sustained as long as the infrastructure is in use. We have calculated this forecasted amount on a conservative basis, as we do not include supply chain effects from the cable investments.[44]

In line with the telecommunication economics literature and, we expect the deployment of connectivity infrastructures of this kind to enable economic actors to reap the benefits of the enhanced and more efficient connectivity. In doing so, *economic actors* can develop new business, make more efficient investments, and improve the terms of business and trade – all of which drive productivity, economic opportunity, and growth – as reflected in the above GDP estimates.

Figure 10
Impact from the forthcoming cables on GDP



Source: Copenhagen Economics based on literature estimates

It is well established in the economic literature that internet infrastructure and usage have positive impacts on macro variables, such as GDP.[45] The impact from subsea cables and the consequent improved internet infrastructure arises from key impact channels onto the whole economy. Underpinning the GDP impact are several *transmission channels*:

1. Trade effects
2. Investment effects
3. Productivity effects
4. Broader economic effects and consumer welfare

In chapter 3, we explain how these infrastructures such as the Equiano subsea cable can lead to increased GDP through each of these transmission channels and explain the effects from the added connectivity on consumer welfare.

43 See the appendix for a description of our methodology. We have calibrated these findings onto data relevant in a Portuguese context. Additional information on conservative assumptions adopted in our forecast calculation method are in appendix. At some point, the cables will be relieved of duty (typically after 25 years), and newer cables will take over.

44 For example, we note that Google has commissioned Alcatel Submarine Networks to carry out the construction of the cable, which will be carried out in Calais, France.

45 See for example the appendix for a list of literature.

CHAPTER 3

SUBSEA CABLES HAVE BROAD ECONOMIC EFFECTS IN PORTUGAL

In this chapter, we explain the main transmission channel for how subsea cables affect the Portuguese GDP for trade effects (section 3.1), investments (section 3.2), productivity (section 3.3), and broader effects and consumer welfare (3.4). While these transmission channels apply to EllaLink as well, we focus only on the transmission channels for Equiano in this chapter.

3.1.1 Trade effects

If countries were closed off and did not trade, every country would have to produce all products for their own consumption themselves, and consumers would have access to fewer varieties of goods and services, as some raw materials and vegetation only exists in few locations around the world and production assets could not be sufficiently installed in all countries.

With trade, countries can specialise in certain products, where they have comparative advantages, i.e., where they are relatively more productive *given* their inputs to production. Comparative advantages and trade secure optimal allocation of labour and capital in the production of goods and services, leading to efficient production, lower prices, and higher consumer welfare (see section 2.4).[46] Thus, trade is a *driver of GDP growth*.

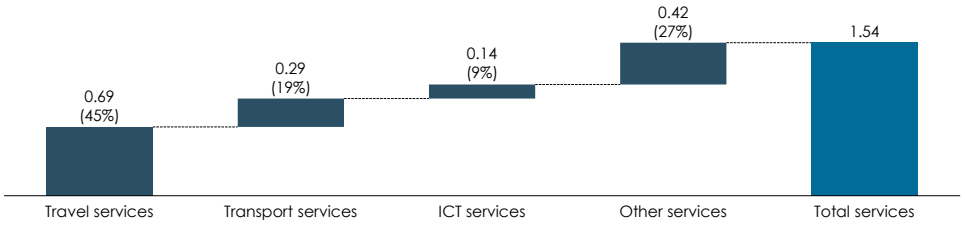
The digital transformation of the Portuguese economy has important trade implications. e-commerce and digital products are increasingly dependent on digital trade, and the demand for digital services increase in many industries.[47] This means that both goods trade and especially services trade are becoming increasingly dependent on digital products.

Digital trade is inextricably linked to the process of digital transformation, which transcends the ICT sector per se. In fact, if we were to focus on the ICT sector in isolation from the rest of the economy, only a partial picture of the potential of digital trade would emerge. In 2019, just 9% (€140 million) of Portuguese services exports to African countries were ICT services (see Figure 11) while digital trade is much broader than just ICT-exports.

It has been estimated that 20% of Portugal's services exports were in so-called *potential ICT-enabled* services industries in 2017, i.e., the services exports were *relying* on ICT in some way or the other.[48] Similarly, ICT and digital services are also key to enable certain goods exports. Therefore, the value of Portuguese digital exports to African countries is already much larger than €140 million –with a potential to increase more beyond this.

46 See for example Arnaud Costinot (2009).
47 Based on input-output data from WIOD and Brookings (2019)
48 OECD, WTO, and IMF (2020), p. 19

Figure 11
Portuguese services exports to African countries, 2019
EUR billion



Source: Copenhagen Economics based on Eurostat.

Faster, cheaper, and more reliable digital connectivity especially improves the conditions for *services trade* between the connected regions. Goods have to be physically transported from the exporting country to the importing country, whereas services trade can take many different forms, including wholly digital services where no physical transportation is needed.[49]

Equiano is expected to have a *positive impact on trade* between Portugal and Africa. With the establishment of Equiano, the costs of transporting data between Portugal and Africa are lowered, and bandwidth increases and latency decreases. Portuguese companies that already trade with African countries are likely to increase their exports, and more companies are likely to start exporting, which would lead to increased trade between Portugal and African countries, *all things equal*.

Improved digital connectivity is found to increase trade. For example, a doubling of the number of internet cables is found to increase exports by 8% for low-income countries,[50] and similar results are found for high-income countries.[51] In Asia, a 10% increase in broadband for exporters and importers is found to increase exports and imports by 18% and 11%, respectively,[52] and in Nigeria, financial services have experienced steep increases in exports after the arrival of subsea cables.[53]

The improved digital opportunities are particularly important for small- and medium-sized companies (SMEs).[54] Companies can more efficiently exchange ideas, information, and other data,[55] and barriers to entry and expansion in the connected markets are reduced. Since barriers are often relatively larger for smaller companies than for larger companies, then it is particularly smaller companies that benefit relatively more when these barriers are lowered.

Finally, connectivity infrastructures, such as subsea cables, can only deliver their fullest economic benefit to companies when framework conditions are conducive to trade and international value chains in any industry subject to digital transformation. The key principle of trade economics is the efficient division of labour between activities (within value chains, between companies, within a company). A key factor to enable an efficient growth in *digital trade* is the exchange and free flow of

49 See for example World Trade Organization (2021).
50 El-Sahli,Z (2020), p. 2-3.
51 Cariolle et. Al. (2020).
52 Asian Development Bank Institute. (2015), p. 18-19.
53 O'Connor, et al. (2020), p. 10.
54 Meltzer (2014), p.1
55 Hillman (2021), p. 1

data as required to underpin different companies' choices on how to organise the development and provision of their products and services. In other words, there is no point in enhancing connectivity infrastructures, including subsea cables, if businesses do not have the free flow of data framework conditions that are a key basis for companies to develop their business and foster all the opportunities from digital trade.

3.1.2 Investment effects

Foreign direct investments (FDI) are often thought of as a growth enabler, as it is an inflow of external capital into an economy. FDI enhance the capital stock in a country, which increase the *productivity per worker*, as workers on average have more tools, equipment, machinery, IT to do their job.

Companies' decisions to invest abroad are influenced by many factors such as quality of infrastructure, market access and barriers to surrounding markets.[56]

Strong digital infrastructure, including subsea cables, is found to be an important driver for investment in data centres in Finland, Ireland, and Scotland,[57] and the new data centre that has been announced in Portugal.[58]

Equiano is expected to have a positive impact on FDI going to Portugal, which would have a positive impact on Portuguese GDP. Furthermore, foreign investors may bring high-skilled workers to Portugal, which would also increase GDP from an increase in high-productive employment in Portugal.

With Equiano, Portugal becomes a more attractive investment location as a digital gateway to Africa, including Portuguese-speaking countries.[59] The cable increases the market access for European companies in Africa, as it lowers the barriers to the African markets from Portugal, making Portugal more interesting as an investment location for foreign investors, *all things equal*.

The Portuguese government is also expecting that Portugal becomes more attractive with Equiano and that Equiano "*gives Portugal additional value to attract investment in the area of ICT and data processing, which allows jobs generation in systems engineering, telecommunications, and mathematics*".[60]

The continuous development of digital infrastructure in combination with high-skilled people in ICT gives Portugal a competitive advantage for attracting FDI. Several regions in Portugal, especially the coastal regions on the west coast, are already attractive locations for foreign investors, also relative to comparable regions in Europe.[61]

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56 For example, see Franco et al. (2008) and Fugazza & Trentini (2014).

57 Copenhagen Economics (2017), p.37 and Vodafone (2021), p.12, and IDA Ireland (2020), p. 5-6.

58 Start Campus announced the construction of a new data centre in Sines, Portugal supporting jobs in the ICT industry in Portugal, see Sapo (2021).

59 EY (2020), p. 8-9.

60 Quote from Secretary of State for Internationalization in Portugal. Translated from República Portuguesa (2019).

61 Copenhagen Economics (2017), p. 21, 34, 40 report prepared for ESPON.

3.1.3 Productivity effects

Productivity is considered a key source of economic growth and competitiveness. The positive impact of fast and reliable internet connectivity on labour and capital productivity are well documented in the literature.[62]

Cloud services, and the internet at large, play important roles as productivity enhancers, as they enable consumers, businesses, and governments to work and carry out daily tasks more effectively and efficiently.

These productivity gains of the modern internet would not take place without key supporting infrastructure, including subsea cables such as Equiano, which enable the following:

- Teleworking and online meetings, reducing cost of and time spent on commuting and business travel, thereby maximising the time spent working.[63] Employees can communicate more effectively and efficiently via instant messaging, email, and video conferencing tools.[64]
- Greater and more sophisticated collection, storing and processing of data, leading to more informed commercial and operational decision-making.[65] Geographically dispersed employees can work collaboratively on online documents and access shared files in the cloud.[66]
- Automation of tasks, e.g., routine customer service transactions, chatbots, and visual bots.[67]
- Increased innovation and improved product designs and business processes, including online marketing, customer engagement, inventory optimization, and streamlining of supply chains.

Across EU countries, a 10 percentage-point increase in the share of companies with access to high-speed broadband is associated with increased multi-factor productivity by 1.9% and 3.9% for an average company after one and three years, respectively. Productivity-enhancing effects are conditional on fast and reliable internet, and that the supporting ICT ecosystem is sufficiently developed.[68]

In addition to productivity effects from more efficient use of the internet, improved digital infrastructure can also create benefits as workers may shift to the high-productive ICT industry from less productive industries over time. Digital employment is likely to become relatively more attractive in Portugal resulting in economic transition thanks to the higher productivity fostered by the use of efficient, affordable, and available ICT infrastructure.

3.1.4 Broader effects and consumer welfare

Improved digital connectivity brings a variety of other socio-economic benefits, which go beyond the most obvious economic indicators, such as productivity, trade, and FDI. This includes improvements in consumer welfare, healthcare, and education.

With the expanding digital connectivity, consumers get access to more affordable internet and access to new goods and services such as digital content, products, and services.[69]

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62 See for example: Deloitte (2016), Andrianaivo & Kpodar (2011).
63 Andrianaivo & Kpodar (2011).
64 Deloitte (2016).
65 Balachandran & Prasad (2017).
66 OECD (2019, b).
67 Andrianaivo & Kpodar (2011).
68 Waverman (2009).
69 RTI (2020), p.8.

The utility that consumers get from consuming a good or service is called **consumer welfare**.[70] Consumer welfare is difficult to measure, as it is consumers' intrinsic valuation of a product. It is often measured as consumers' willingness to pay for a given good or services *minus its price*.

Access to fast and reliable internet increases consumer welfare from three channels:[71]

- **Income effect:** Lower prices and easier information gathering increase consumers' possibilities to increase their consumption or buy better quality products.
- **Love of variety:** Online, consumers have access to a broader variety of products, which increases consumer welfare as there are more options to choose from.[72]
- **Product quality enhancements**: Improved quality of products and low unit cost arising from digitally driven productivity increases in the transformation of existing products into digital products, e.g., from DVD to video streaming.

Through the internet, consumers gain access to new distribution channels of existing products, (e-commerce, music and video streaming, software etc.), as well as new low-cost digital products (cloud, search engines, social media etc.). Consumers also benefit from higher quality products and services, as digitally driven productivity growth can drive innovation, e.g., via automation.

Digital products can more easily be scaled than traditional goods and can generate much larger consumer welfare because of this scalability. For example, instead of buying a DVD to watch one movie, consumers can subscribe to streaming services and get access to a range of movies and series, whenever and wherever the consumer prefers.

Many purely digital goods, which are provided at zero or close to zero costs to consumers, such as digital maps, social media, search engines, and instant messaging apps can also lead to substantial utility for consumers, though these are more difficult to quantify. According to an online choice experiment, the median internet user would require compensation of USD 17,530 (€14,500) to forgo search engines for a year in the US. To lose access to email and to forgo digital maps for a year, the median internet user would require compensations of USD 8,414 (€6,970) and USD 3,648 (€3,020), respectively.[73]

On an aggregate level, empirical findings suggest high net consumer benefit from broadband access. The improved quality of the internet from the change from dial-up to broadband was found to increase consumer welfare in Portugal by equivalent to USD 5.2 billion (€4.3 billion) in 2010.[74]

In **healthcare**, increased and improved connectivity enable healthcare providers to deploy new digital solutions and ways of working, resulting in improved patient outcomes as possible cost reductions.[75] Examples include:

- Telecare and remote surgeries, allowing for physicians to treat patients from different locations.[76]

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70 Utility is an economic term that refers to the total satisfaction received from consuming a good or service.
71 Copenhagen Economics (2021), p. 21-22, OECD (2012), p. 1, 11-12.
72 See Hummels & Lugovskyy (2005), Copenhagen Economics (2009).
73 Brynjolfsson et al. (2019).
74 Greenstein & McDevitt (2012), OECD Digital Economy Papers, No. 197
75 Deloitte (2015).
76 OECD (2012), p. 16

- Improved data transfer possibilities, allowing for data of varying types and sizes to reach destinations at quicker speeds.
- Improved data processing and analytics, such as artificial intelligence, allowing for more timely and potentially more effective diagnosis, treatment, and disease prevention.
- Digital patient apps and the support of digital home care allow patients to receive more personalized and convenient care.

For **education**, the benefits of improved and increased connectivity are similar to those in healthcare. Educational services delivered to students can to a larger extent become digital, resulting in improved quality of and access to education.[77]

- Increased connectivity can unlock educational opportunities for rural populations that can partake in studies remotely, for example supported by video conferencing or online learning courses.[78]
- New digital education tools and apps that individuals can access directly from their mobile devices.
- This can help close some of the educational divide and also support the transformation of low-skilled workforce to a more medium- or high-skilled workforce in low-income countries.

[77] Broadband Commission for Sustainable Development, International Telecommunication Union, UNESCO, United Nations Children's Fund (2020).

[78] OECD (2012), p. 15.

CHAPTER 4

POLITICAL AND ECONOMIC COHESION WITH AFRICA IS PARTICULARLY IMPORTANT TO PORTUGAL

In this chapter, we consider Portugal's political engagement in Africa in section 4.1, and we dive into the trade and investment relations between Portugal and African countries in section 4.2.

4.1 PORTUGAL IS POLITICALLY COMMITTED TO AFRICA

The relationship between the EU and Africa has been characterised as a key topic of the Portuguese Presidency of the EU by the Portuguese Minister of Economy Pedro Siza Vieira, see Box 6. Equiano "*reinforces the centrality of Portugal in the relationship of communications with Africa*".[79]

Box 6 African-EU relationship is a top priority for the Portuguese Presidency

Portugal is focusing on three main priorities in its EU Presidency:

1. **Promote the European recovery boosted by the green and digital transitions.**
   Acceleration of the technological transition and promote European leadership in the digital economy.
2. **Delivering the European Union's Social Pillar as a key element for ensuring a fair and inclusive green and digital transition.**
   The Presidency's mission is to strengthen trust in the European social model […] strengthening the capacity to respond to public health crises and efforts to produce and distribute safe vaccines accessible throughout Europe and the rest of the world.
3. **Strengthening the strategic autonomy of a Europe that is open to the world.**
   Continue strengthening of the EU's presence in the world, promoting multilateralism and diversifying global partnerships, in particular with the European Neighbourhood, Africa, the India-Pacific region and the entire transatlantic area.

   A special emphasis is given on **making Europe more digital**, with the strategic creation of a European Data Entry Platform based on submarine cables, **in particular for links between Europe, Africa and South America**. These links contribute to greater European digital autonomy, linking infrastructures and data.

   Special focus is put on the **relationship between the EU and Africa**. With the sixth EU-Africa Union Summit, special emphasis will be placed on the green transition in Africa. The main goal will be to **deepen the trade relationship with Africa** and contribute to the African Continental Free Trade Agreement.

Source: 2021 Programme for the Portuguese Presidency of the Council of the European Union

79 dinheiro vivo (2019) & República Portuguesa (2019).

Portugal has historical ties to Africa, and there are still strong political, trading, and investment relations between Portugal and Lusofonia countries such as Angola, Cape Verde, and Mozambique. Portugal invests in maintaining strong political ties with many of these countries, ensuring bilateral economic, educational, scientific, and technological cooperation.[80] This entails both the work of qualified labour from Portugal supporting growth in these economies, as well as Portuguese financial services fostering an interconnected international financial economy with these trading partners.[81]

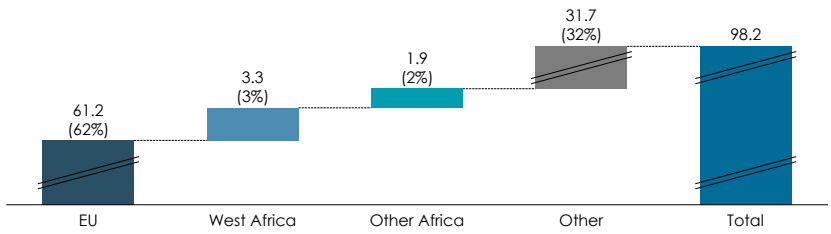
4.2 PORTUGAL AND AFRICAN COUNTRIES HAVE GOOD TRADE AND INVESTMENT RELATIONS

4.2.1 Trade relation

The EU-African trade is reflected in the program of the Portuguese Presidency of the Council, which states that the presidency will work towards strengthening the trade relationship with Africa and contribute to the African Continental Free Trade Agreement.[82]

Portuguese exports to the 25 West African countries that face the Atlantic Sea - thus within actual or potential reach of Equiano, totalled €3.3 billion in 2019, relative to €1.9 billion for the remaining 33 African countries and territories, see Figure 12. In total, 5% of Portuguese exports went to African countries in 2019 (14% of extra-EU exports). Portugal's main trading partner remains the EU single market, which is the destination for 62% of all Portuguese exports.

Figure 12
Portuguese exports of goods and services, 2019
EUR billion



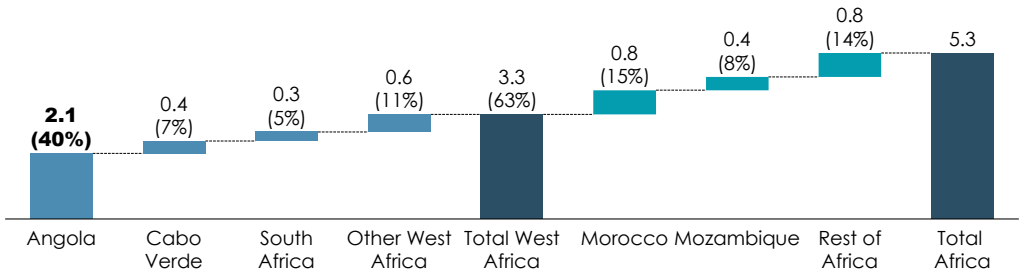
Note: "West Africa" covers Angola, Benin, Democratic Republic of Congo, Congo, Côte d'Ivoire, Cameroon, Cabo Verde, Western Sahara, Gabon, Ghana, Gambia, Guinea, Equatorial Guinea, Guinea-Bissau, Liberia, Mauritania, Namibia, Nigeria, Saint Helena, Ascension and Tristan da Cunha, Sierra Leone, Senegal, Sao Tome and Principe, Togo, and South Africa.
Source: Copenhagen Economics based on Eurostat.

Portugal has a long trading history with several African countries, in particular Angola, Cabo Verde, and Mozambique. Outside the EU, Angola was the third largest export destination for Portuguese goods after the UK and the US, reaching €2.1 billion in 2019, see Figure 13. In 2019, Portuguese

[80] Portal Diplomático (2020).
[81] This is Africa (2015)
[82] 2021Portugal.EU (2021), p. 35

exports to African countries were €5.3 billion. In comparison, Portuguese imports from African countries reached close to €4.8 billion in 2019.

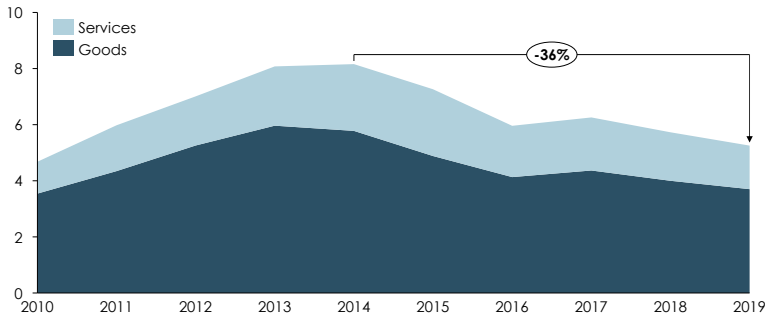
Figure 13
Destination of Portuguese exports of goods and services to African countries, 2019
EUR billion



Note: "West Africa" covers Angola, Benin, Democratic Republic of Congo, Congo, Côte d'Ivoire, Cameroon, Cabo Verde, Western Sahara, Gabon, Ghana, Gambia, Guinea, Equatorial Guinea, Guinea-Bissau, Liberia, Mauritania, Namibia, Nigeria, Saint Helena, Ascension and Tristan da Cunha, Sierra Leone, Senegal, Sao Tome and Principe, Togo, and South Africa.
Source: Copenhagen Economics based on Eurostat.

However, while Portugal has important exports to Africa, the total exports to Africa has declined in recent years. Portuguese exports to African countries have declined by 36% since 2014 for both goods and services, see Figure 14. This happened after a period of increasing Portuguese exports to Africa. There is scope for improving the Portuguese trade with African countries.

Figure 14 Portuguese exports of goods and services to African countries, 2010-2019
EUR billion



Source: Copenhagen Economics based on Eurostat.

As with any new major infrastructure, a subsea cable that delivers significant added capacity can promote trade, by reducing transaction costs and capacity constraints. This can benefit a range of industries, given the wide set of economic activities which use international connectivity.

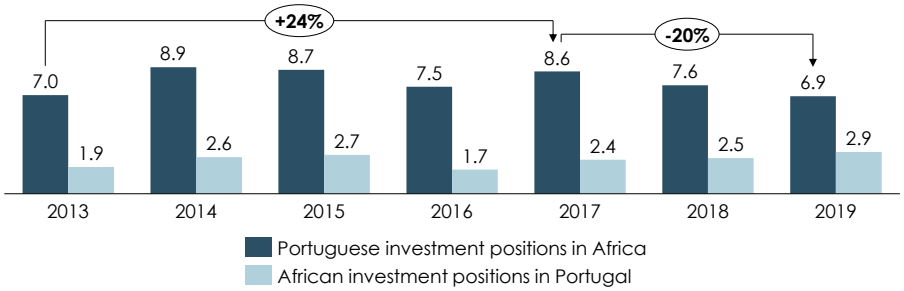
4.2.2 Investment relations

During its presidency of the EU, Portugal, and European Investment Bank (EIB) organised an EU-Africa forum on the green economy and green investment in April 2021. The aim was to strengthen investment between the two continents especially for green investment and the energy transition.[83]

Portugal's close connection with several African countries is also seen in the Portuguese investment positions in Africa. In 2019, Portuguese investment positions in Angola and Mozambique were €2.2 billion and €1.5 billion, respectively, covering more than half of Portuguese investments on the African continent. Notably, African investments in Portugal have grown by nearly 50% over the 2013-2019 period, with total investment positions reaching a value of €2.9 billion in 2019.

However, Portuguese investment positions in Africa have declined since 2017, see Figure 15. In 2017, Portuguese investors had more than €8.6 billion invested in African countries. This was an increase of 24% from 2013 to 2017 and covered almost 15% of all foreign Portuguese investment positions in 2017. From 2017 to 2019, the Portuguese investment positions in Africa declined 20%. Contrarily, African investment positions in Portugal have increased in recent years.

Figure 15 Portuguese and African investment positions
EUR billion



Source: Copenhagen Economics based on number from Eurostat.

One way that can help reverse the declining Portuguese trade and investment with Africa is for Portugal to reap the benefits of the added connectivity from Equiano. According to the Portuguese Chamber of Commerce, there are in particular possibilities in:

- **Nigeria:** There is large potential for Portuguese companies in Nigeria, especially in sectors where Portuguese companies have a comparative advantage, including telecommunications, construction, and real estate.[84] Portuguese imports from Nigeria (€1 billion in 2019), consisting mainly of minerals, greatly exceeds its exports from Nigeria (€31 million).[85]
- **South Africa:** South Africa has the potential to be a key strategic market for Portuguese investments and for Portuguese companies looking for business opportunities in Southern Africa outside the Portuguese speaking countries Angola and Mozambique.[86] South Africa is also interesting as an entry to the Southern Africa Development Community (SADC), facilitating market access for Portuguese companies to 14 other African countries as well.[87]

83 See European Investment Bank (2021).
84 Câmara de Comércio e Indústria Portuguesa (Chamber of Commerce, b).
85 Source: Eurostat.
86 Câmara de Comércio e Indústria Portuguesa (Chamber of Commerce, a).
87 Câmara do Comércio e Indústria Luso-Sul Africana (CCILSA).

CHAPTER 5

POLICY MAKERS CAN PLAY AN IMPORTANT ROLE ENABLING THE CONTINUOUS, FAST ENHANCEMENT OF THE INTERNET AND UNDERPINNING CONNECTIVITY

In this chapter, we first describe how Portugal's framework conditions are good for subsea cable investments in section 5.1. In section 5.2, we describe what framework conditions policy makers can work towards to assist investments in digital infrastructure and connectivity.

5.1 PORTUGAL HAS GOOD FRAMEWORK CONDITIONS FOR INVESTMENTS IN SUBSEA CABLES AND MORE CAN BE DONE

Portugal has become a hub for subsea cables, not only because of its strategic geographical position as mainland Europe's most South-Western area, but also because of the country's focus to develop and strengthen the digital economy in Portugal. Many of the existing cables landing in Portugal are relatively old, have limited bandwidth, and are more expensive to maintain relative to newer cables. The new high-capacity cables increase the international bandwidth landing in Portugal greatly.

The Portuguese Government is focusing on continuous development of Portugal as a technological platform that tests advanced technological solutions and attracts external ICT investments to develop and test new digital solutions for cities, networks, resource management, and mobility.[88]

Portugal is doing many things well in developing the ICT industry in Portugal and has also raised the importance of subsea cables under its presidency of the EU. The Portuguese Digital Plan focuses on developing the ICT industry in Portugal, see Box 7. Portugal is positioning itself as a more digitalised economy for both public and private actors.

[88] Silva, António Costa (2020).

Box 7 Portuguese Digital Plan

Portugal is committed to transition into a more digital economy. Currently, the country is home to 2,500 registered start-ups, 162 incubators, and three unicorns. The ICT sector employs over 25,000 people, representing 1.1% of the GDP.

Portugal Digital has the purpose to accelerate Portugal digitally through digital empowerment of people, digital transformation of businesses, and the digitalisation of public administration. For the continuous growth of the sector, the Portuguese government has drafted an Action Plan based on three pillars:

1. **Training and inclusion of people:** Digital education, requalification and vocational training, inclusion, and digital literacy.
2. **Digital transformation of businesses:** Entrepreneurship and investment attraction, SMEs, and transfer of scientific and technological knowledge to the economy.
3. **Digitalisation of the public administration:** Digital public services, more agile and open central administration, and connected regional and local administrations.

Six catalysts are built upon the pillars I) Regulation, cybersecurity, and privacy, II) Circular data economy, III) Connectivity and infrastructures, IV) Disruptive technologies, V) Alignment with the European Digital Strategy, and VI) Communication and promotion.

Source: Portuguese Government (2020): *Action Plan for Digital Transition*

In some areas, Portuguese policy makers could do more to spur investments and development in ICT. Portugal is behind the EU average in the share of population using the internet. In 2019, 75% of the Portuguese population used the internet, compared to the EU average of 85%.[89] In addition, Portugal ranked 19th out of the 27 EU member states in the Digital Economy and Society Index in 2020.[90]

The lack of human capital for digital abilities is limiting Portugal's ICT development. 26% of the Portuguese population has no digital abilities at all, and the proportion of ICT specialists (2.4%) of the workforce is lower than the EU average (3.9%)[91]. In 2019, Portugal implemented the national initiative on digital competencies as an effort to improve the digital skills of the population, which may turn this development.

Portuguese SMEs are less active in digitisation than large companies, and 16% of Portuguese SMEs sell online, which is slightly below the EU average of 18%. This is particularly important because the Portuguese economy is mostly dominated by micro enterprises concentrated in traditional sectors.[92]

89 World Bank Database (2021).
90 European Commission (2020, b).
91 European Commission (2020, b).
92 European Commission (2020, b).

Portugal has a unique opportunity to develop its ICT industry with the new large-scale subsea cables landing in Portugal in 2021-2022, as the subsea cables digitally connect Portugal to Africa and South America and power the global growth of the internet through added connectivity. In turn, this enables better local user experience and global internet traffic stability in Portugal, benefitting consumers, businesses, and the government, as described in chapter 1 and 2. There is room for Portugal to grow on a global scale, while Portugal needs to take full advantage of what the digital world has to offer. The Portuguese Digital Plan is a good step to develop the digital economy in Portugal.

One way is to accelerate the process of digital transformation in public administration to achieve gains in efficiency, transparency, and service to the citizen, thereby guaranteeing cost reduction and control in the medium and long term.[93]

Portugal should continue to invest in human capital, attract foreign investments in ICT, and develop its digital infrastructure to boost its digital economy.

5.2 GOOD FRAMEWORK CONDITIONS ARE ESSENTIAL FOR ENABLING SUBSEA CABLES' CONTRIBUTION TO DIGITAL DEVELOPMENT

In a joint call for a *European Data-Gateway Platform Strategy*, almost all the EU member states, including Portugal, call for action to increase EU's digital connectivity with the rest of the world and to develop the EU's capacity to store and process data.[94] According to senders of the call, the EU is missing out on the opportunities in the digital economy. The EU must improve its internal *and* external capacity by building connectivity with global subsea cables from Europe to Africa and Asia, where there is especially room for improvement. The call acknowledges that "*international connectivity supports and accelerates the competitive digitalisation of the EU economy. It increases productivity, provides unique business opportunities, ensures equal access to fast internet connection throughout Europe's regions, ultimately benefiting consumers.*"[95]

Slow development in subsea connectivity in Europe could result in a loss of competitiveness for European companies, relative to companies in countries with better connectivity.[96] For the internet to function and continuously develop, investments in subsea cables will continue going forward.

The result of continuous investments in connectivity is a vibrant domestic and international telecommunication sector, not just for the specific landing spot in coastal European areas, but also for inland and land-locked European areas that are connected to the world through the terrestrial cables to the subsea cables. International investments in cross-continent subsea cables are key to the continuous, efficient flow and exchange of data.

Indeed, the efficient and free flow of data is a key underpinning of the enhancement of digital trade between nations. Connectivity infrastructures, such as subsea cables, can only deliver their fullest economic benefit to companies when framework conditions are conducive to trade across digital,

93 Sapo (2020).
94 Call for a "European Data-Gateway Platforms strategy" as part of "Shaping Europe's Digital Future" (2021)
95 Ibid. p. 3
96 Hillman (2021), p. 13. A US context adapted for Europe.

international value chains. A key factor to enable an efficient growth in *digital trade* is the exchange and free flow of data as required to underpin different companies' choices on how to organise the development and provision of their products and services. Products, services, information, and data are often intertwined and exchanged at once when Company A supplies Company B in a value chain. There is no point in enhancing connectivity infrastructures, including subsea cables, if businesses do not have the free flow of data framework conditions that are key to exchange inputs, products, and services efficiently between each other and foster all the opportunities from digital trade.

Deployment of backbone infrastructure networks, such as subsea cables, is necessary for connecting European countries to third countries and ensure territorial cohesion.[97] Significant upgrades of cross-border backbone networks linking the EU to other countries should be prioritised when they significantly contribute to the performance of the digital infrastructure.[98] However, these projects are not always viable without public support.

Private investors in subsea cables are important for ensuring that new cables are state-of-the-art quality. When companies like Google invest in subsea cables, they bring with them engineering innovations and push the boundaries for technical efficiency, contributing to lower latency and improved bandwidth and reliability. Google's investments in subsea cables are furthermore part of broader investments that include edge network, which reduces costs for ISPs.[99]

Good framework conditions are important for the development of internet infrastructure and cloud services, as investments in subsea cables and edge infrastructure are necessary to ensure reliable and effective cloud take up by businesses and governments.[100]

To create good conditions for investments in international digital connectivity, policy makers can consider the following policy actions for *deploying subsea cables*, *maintenance of subsea cables*, and *general policies and political vision*:[101]

Deploying subsea cables

1. Continue to have transparent procedures and build on efficient licensing and permit processes for deploying cables.
2. Create a centralised single point of contact for licenses and permits for subsea cables. Obtaining permits and licenses can require involvement of multiple stakeholders for example from departments for land, marine, environmental, and urban planning, and in some cases private fisheries organisations.
3. Continue to develop an open environment for investors, including:
    - Enabling foreign investors to invest in, own, and operate subsea cables.
    - Supporting commercial incentives for private sector investment to invest in international connectivity.
    - Providing access to competitive financing for international connectivity investments.

97 Letter from General Secretariat of the Council to the Permanent Representatives Committee (2021), p. 21
98 Ibid, p. 44
99 Analysys Mason (2020), p. 28.
100 Cloud computing is much more efficient than decentralised storage, and cloud can reduce a company's energy use for computing storage by 68-87%. Google (2021).
101 In addition to the literature already presented in this chapter, see Deloitte (2018), p.13 and Hillman (2021), p.19-20, adapted conclusions from the paper from a US to an EU context, Analysys Mason (2020), p. 59-65.

- Making public-private partnerships possible for investing in new subsea cables.
- Avoiding potential monopoly situations for landing stations and enhance competition for current incumbent providers to avoid market concentration.

4. Avoid concentration of landing stations to mitigate risk of multiple outages by ensuring that multiple landing stations sites are available. Geographic distribution ensures resilience, which is important for business continuity in the event of disruptive instances such as cable outages. In addition, policy makers can ensure that investors can influence where to place landing stations, as companies can optimise their landing station location and increase the resilience of their network.
5. Secure consistent regulation for cable protection zones around cable landing locations.
6. Ensure swift procedures to amend existing licences (TUPEM) in situations where the substance of the subsea cable coastal activity is unchanged – for example when the overall cable system gets enhanced via main cable ramifications / extensions that were not foreseen at the time of the original TUPEM (which currently requires a new administrative authorisation)

Maintenance of subsea cables

7. Continue to have fast-tracked permit application process for inspection and repair work for quick responses to repair potential damages or problems with the cables.
8. Subsea cable maintenance should be exempt from cabotage laws, meaning that service ships do not have to sail under the flag of the landing country in territorial waters.
9. Cable production laws are implemented and effectively enforced, and damage to subsea cables could be penalised.

General policies and political vision

10. Continue to support a vibrant, competitive telecommunications industry - in particular as to the supply of business connectivity (leased lines) alternative infrastructures and services. These services are key not just for complementing subsea cable connections but also for many advanced and high-capacity applications serving domestic and international business (fixed and mobile retail telecoms, finance and professional services, healthcare, university/research, advanced manufacturing).
11. Support high-quality ICT education.
12. Safeguard the free flow of data, to enable large and small businesses to tap into the maximum potential of business opportunities from digital trade.
13. Foster greater clarity and reduce mismatches in tax treatment between countries (via EU-harmonisation), e.g. by Tax Authority guidance on tax (e.g. VAT) treatment of transactions involving subsea cables (such as construction, maintenance, supply of dark fibre, supply of capacity).
14. Support low- and lower-middle-income countries in their digital development, thus ensuring greater use of the subsea cables deployed to these countries.

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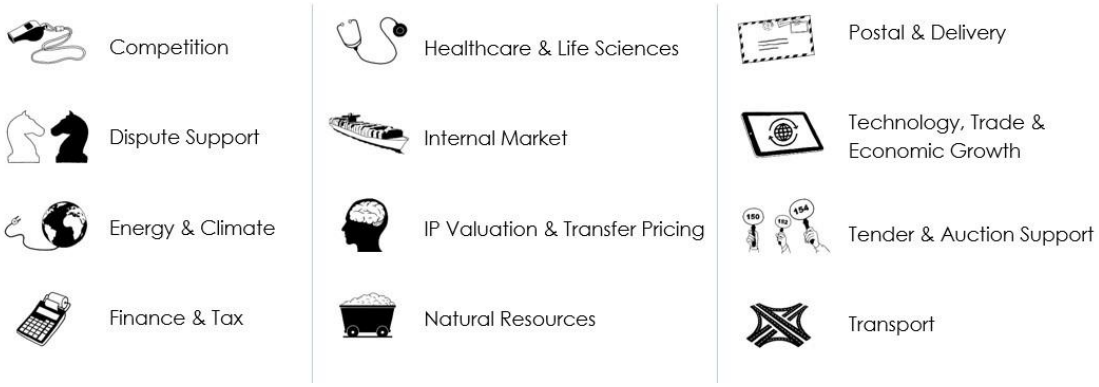

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APPENDIX A

METHODOLOGICAL APPROACH

The appendix consists of two sections.

i) Our method for calculating the GDP impacts.
ii) Additional Literature assessed

I) OUR METHOD FOR CALCULATING THE GDP IMPACTS

We calculate the GDP impact from Equiano and EllaLink using two main channels: **Internet bandwidth** and **latency**. The impact is calculated based on the main literature associating subsea cables and GDP growth. Temporary construction effects are not assessed.

We use the results found in Analysys Mason (2020) which estimates impact on GDP from subsea cables in APAC countries. The impact stems from increased bandwidth and lower latency from subsea cables, which increases demand for mobile broadband, which in turn increases GDP. In this estimation, several transmission impacts are impacting to the economy, including the transmission channels discussed in this report.

The GDP estimation in Analysys Mason (2020) is made in a sequence of three steps, each based on a stand-alone econometric regression:

1. The report finds the impact of *an additional subsea cable* on latency and internet bandwidth.[102] The estimators are measured as a percentage increase in the number of subsea cables with the introduction of a new cable.

   - **Elasticity for internet bandwidth: 4.05**, i.e., a 10% increase in the number of subsea cables increases the internet bandwidth by 40.5%.
   - **Elasticity for latency: -1.36**, i.e., a 10% increase in the number of subsea cables decreases the latency by 13.6%

2. Then, the report finds the impact of international internet bandwidth and latency on mobile internet data use.

   - **Effect of internet bandwidth: 0.63**, i.e., a 10% increase in internet bandwidth increases the mobile internet data use by 6.3%
   - **Effect of latency: -0.54**, i.e., a 10% increase in latency decreases the mobile internet data use by 5.4%

3. At last, the report finds the impact of mobile internet data use on GDP.

   - **Effect of mobile internet data use on GDP: 0.008**, i.e., a 10% increase in mobile internet data use increases the GDP by 0.08%

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[102] Internet bandwidth is here defined as "*the total used capacity of international internet bandwidth; measured as the sum of capacity of all internet exchanges offering international bandwidth*".

We use these literature findings in the estimation of the GDP impact. These findings reflect the economic relationships in a set of APAC countries over the past decade. This is a different geographic and temporal context than Portugal and European connectivity looking ahead to the 2020s. It is likely that some of the GDP growth effects identified historically in the APAC region have been stronger than it would be for Portugal, which is a more developed economy and is already digitally connected with subsea and terrestrial cables. For this reason, we choose to use the lowest bound of the impact results from the APAC study, when applying onto the Portuguese case.

Thus, as a conservative estimate, we use the lower bound 95th-percentile of the results reported in the Analysys Mason (2020) study. We achieve this by scaling down the result by a *conservative factor* of 46.6%, which is the ratio between the lower conservative impact and the base-case impact reported in that study for "bandwidth and edge network", thus $\frac{\text{USD 118 billion}}{\text{USD 253 billion}} = 46.6\%$.[103]

Using these estimates, we find the following impacts of Equiano and EllaLink on Portuguese GDP through the two channels: internet bandwidth and latency:

$$\begin{aligned}\text{GDP impact}_{\text{Channel,year}} &= \text{Pct. increase in no. of cables} * \text{Impact of cables on channel} \\ &* \text{Impact of channel on mobile internet data use} \\ &* \text{Impact of mobile internet data use on GDP} * \text{Portuguese GDP}_{\text{year}} \\ &* \text{Conservative factor}\end{aligned}$$

There are currently 10 subsea cables landing in Portugal. With the addition of Equiano and EllaLink, there will be 12 subsea cables landing in Portugal.[104] This is an **increase in the number of cables by 20%**.[105] As Portuguese GDP is forecasted to be €220.5 billion[106] in 2022 (2020-prices), we find that:

[103] See Analysys Mason (2020), page A-17, Figure A.8.

[104] There may soon be other cable landings in Portugal, e.g., the 2Africa link is expected to finish in 2023.

[105] Based on count of cables in Forum Analytics (2021): *Submarine Cable Almanac, issue 37*

[106] The GDP in 2022 is calculated based on the GDP in 2020 from Eurostat and forecasted real GDP growth for 2021 and 2022 from IMF.

Table 2
Summary structure of estimation of the GDP impact for the two channels

	Internet bandwidth effect		Latency effect	
Chock to the Portuguese economy: Increase in the subsea cable capacity from 10 to 12 cables	+ 20 %		+ 20 %	
Impact of subsea cables on channel	4.05		-1.36	
Impact of channel on mobile internet data use	0.63		-0.54	
Impact of mobile internet data use on GDP	0.0008		0.0008	
Impact of a 1% increase in number of subsea cables on GDP		**≈0.0205** = 4.05 x 0.63 x 0.0008		**≈0.0059** = -1.36 x -0.54 x 0.0008
Portuguese GDP, 2022 forecast	€220.5 billion		€220.5 billion	
Conservative factor	46.6%		46.6%	
Impact on GDP	**+ €0.42 billion**		**+ €0.12 billion**	

Note: The impact on GDP is found by multiplying the numbers in the columns.
Source: Copenhagen Economics based on Analysys Mason (2020) and Eurostat

To sum up, our calculation is:

$$\text{GDP impact}_{\text{Internet Broadband},2022} = 20\% * 4.05 * 0.63 * 0.008 * €220.5\text{b} * 46.6\% = €0.42 \text{ billion}$$

$$\text{GDP impact}_{\text{Latency},2022} = 20\% * (-1.36) * (-0.54) * 0.008 * €220.5\text{b} * 46.6\% = €0.12 \text{ billion}$$

Thus, the total GDP impact is found to be €0.54 billion per year (permanent effect), equivalent to 0.25% of GDP.

In the report, we focus on the combined impact rather than the split between the individual impacts. In econometric analyses there may, to some extent, be multicollinearity when using multiple related regressors to explain a variable, e.g., GDP.

Sensitivity discussion
These estimates are calculated based on results for APAC countries, and there are several aspects such as the current ICT infrastructure, geography etc. that are different in a Portuguese context.

The elasticity for the number of cables' impact on internet bandwidth (4.05) is a simplification of the capacity. There are two (opposing) directions for why this may influence the results for Portugal:

1) Equiano and EllaLink *both* have larger capacity (in Tbit/s) than the *combined* existing capacity of subsea cables in Portugal. When only considering the number of cables, this may not capture the *relative change in capacity*. While this effect could go both ways, it may be that literature finding (i.e., regression parameter of 4.05) may **underestimate** the link between Tbit/s and internet bandwidth, and thus the subsequent impacts on GDP. In addition, several of the existing cables connecting Portugal have relatively low Tbit/s capacity, making them less important for Portugal's digital connectivity, but still lowering the impact from this elasticity.

   To our knowledge, there has not been studies on the impact from the Tbit/s capacity from subsea cables on GDP, which is why we use the number of cables in the estimation.

2) However, Portugal is already well-connected with many global subsea cables *and* European terrestrial cables. Many APAC countries (e.g., Australia, Japan, Indonesia, the Philippines, and Taiwan) can to a large extent *only connect* to the global internet via subsea cables.[107] Therefore, the *additional* effect of a new subsea cable on internet bandwidth and latency in APAC countries may be relatively larger than for Portugal. This means that we risk **overestimating** the impact (the estimator 4.05 would be too high), as the relative importance of subsea cables could be greater in the APAC countries than in Portugal.

Similar arguments can be made for the latency parameter (-1.36).

As we are taking a conservative approach to the estimation, we are confident that we are more likely to underestimate than overestimate the impacts. Other studies find larger results, suggesting that our results are in the conservative end of the impact studies.

- Analysys Mason (2020) finds GDP impacts of USD 118-896 billion over the period of 2020 to 2024, attributable to Google's network investments in APAC countries.[108] This corresponds to an average annual impact of USD 24-179 billion (€20-148 billion). It is difficult to compare this number to our number, as there are multiple steps in the calculations that makes it difficult to assess the percentage change for the APAC countries where Google has invested in network. However, since our estimation is based on the most conservative outcome of this paper, we are confident that this is also reflected in our results.
- RTI (2020) estimates the impact of the 2Africa cable and finds a GDP impact of 0.42% to 0.58% for all of Africa, equivalent to USD 26-37 billion (€22-31 billion) in GDP at purchasing power parity. This also covers land-locked African countries, and African countries not directly linked to the subsea cable. We find a lower percentage for Portugal, and we only calculate the economic impact for a country that is directly connected to the cable.
- Results for the Democratic Republic of the Congo, South Africa, and Malaysia show much larger impact of subsea cables ranging 6%-19% increase in GDP per capita, see next page.

Overall, our results are in the lower end, which we find realistic given Portugal's existing digital connectivity with terrestrial and subsea cables.

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[107] Satellites are also an option.

[108] Analysys Mason (2020), p. A-17. The impact range depends on the connectivity components and modelling scenarios.

II) ADDITIONAL LITERATURE ASSESSED

Table 3
Summary table of studies on impacts on GDP and other economic variables

Variable	Impact on	Region & year(s)	Impacts	Study
Introduction of broadband	**GDP per capita**	OECD countries-25, 1996-2007	Introduction of broadband leas to a 2.7 to 3.9 p.p. GDP per capita growth	Czernich, Falck, Kretschmer and Woessmann (2009). Broadband Infrastructure and Economic Growth
Substitution from 2G to 3G penetration	**GDP per capita**	6 countries worldwide, 2009-2011	10 p.p. increase in 3G penetration increases annual GDP per capita by 0.15 per capita	Deloitte. (2012). What is the impact of mobile telephony on economic growth?
Mobile broadband penetration	**GDP**	Philippines, 2000-2010	10 p.p. increase in mobile broadband penetration was found to contribute 0.32% to GDP	Katz and Callorda. (2012). The economic impact of broadband in the Philippines
International bandwidth consumption per user	**GDP per capita**	South Africa, 1995-2017	0.15% increase in GDP per capita for every 10% increase in international bandwidth consumption per user	RTI. (2020). Economic Impact of 2Africa
International bandwidth consumption per user	**GDP**	Malaysia, 1992-2017	0.24% increase in GDP per capita for every 10% increase in international bandwidth consumption per user	RTI. (2020). Economic Impact of Submarine Fiber Optic Cables and Broadband connectivity in Malaysia
Subsea Cables	**Exports**	Kenya, 2009-2013	3,800% increase in financial services exports	RTI. (2020). Economic impact of 2Africa
Subsea Cables	**Export**	Nigeria, 2010-2017	1,100% increase in financial services exports per capita.	RTI. (2020). Economic impact of 2Africa
Subsea Cables	**Firm Growth**	South Africa, 2007-2014	23% increase in net firm entry per quarter	RTI. (2020). Economic impact of 2Africa
Subsea Cables	**GDP**	Democratic Republic of the Congo, 2012-2017	19% increase in gross domestic product (GDP) per capita	RTI. (2020). Economic impact of 2Africa
Subsea Cables	**GDP per capita**	South Africa, 2009-2014	6.1% increase in GDP per capita	RTI. (2020). Economic impact of 2Africa
Subsea Cables	**GDP per capita**	Malaysia, 2011-2015	6.9% increase in GDP per capita by the end of 2015	RTI. (2020). Economic Impact of Submarine Fiber Optic Cables and Broadband connectivity in Malaysia

Source: Copenhagen Economics based on literature research