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REPORT FOR GOOGLE

ECONOMIC IMPACT OF GOOGLE’S SUBMARINE CABLE NETWORK IN LATIN AMERICA AND THE CARIBBEAN

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Contents

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The analysis contained in this document is the sole responsibility of Analysys Mason and does not necessarily reflect the views of Google or other contributors to the research.

We would like to thank the many industry experts whom we interviewed for the purposes of writing this report.

Acronym	Meaning
CAP	Content and application provider
CDN	Content delivery network
EB	Exabyte
Enacom	Ente Nacional de Telecomunicaciones (Argentinian telecoms regulator)
GDP	Gross domestic product
GGC	Google Global Cache
GSMA	Global System for Mobile communications Association
GVA	Gross value added
IaaS	Infrastructure-as-a-service
IP	Internet Protocol
ISP	Internet service provider
IT	Information technology
ITU	International Telecommunication Union
IXP	Internet exchange point
LAC	Latin America and the Caribbean
PaaS	Platform-as-a-service
PB	Petabyte
PoP	Point of presence
Q&A	Questions and answers
RFS	Ready for service
SaaS	Software-as-a-service
SME	Small and medium-sized enterprise

Executive summary

Ongoing growth in Internet usage in Latin America is supported by network infrastructure investments made by Google and other providers

Internet services are vital in Latin America and the Caribbean (LAC), as well as in other regions around the world. The number of services and products available on the Internet is growing rapidly, resulting in a very large demand that needs to be supplied on an international basis. Following a global trend, Internet traffic within LAC and from LAC to the rest of the world is predicted to continue growing in the coming years.

In this context, the internationally connected network infrastructure over which Internet services are provided is an important asset. Operators and Internet companies, together with some infrastructure investors, are investing in LAC in order to support the traffic growth expected in the region. Intercontinental traffic from Latin America to North America and beyond requires scalable subsea connectivity. In addition, although geographically difficult terrain such as the Andes mountain range and the Amazon River makes it costly and challenging to construct terrestrial inter-country networks, many countries in LAC have ample coastlines to support submarine cables, providing favorable conditions for investments in such cables for international connectivity. These international links complement domestic network infrastructure to offer consumers and businesses effective access to the Internet.

Google is an important stakeholder in the Internet ecosystem, which handles rapidly growing traffic for its users and cloud customers. To manage these growing capacity requirements, Google invests in submarine cable infrastructure in LAC and globally. Google's main objective in deploying these cables is to enable transport capacity between international locations, which contributes to its aim of organizing the world's information and making it universally accessible and useful. New cables can also offer increased redundancy for Google and other submarine cable providers, through mechanisms such as swaps of fiber pairs with other providers.[1] So far in LAC, Google has spearheaded the launch of three international submarine cables: Monet (linking Brazil and the US), Tannat (connecting Argentina, Uruguay, and Brazil) and Curie (connecting Chile, Panama, and the US). Google has also launched a domestic cable in Brazil, Junior, which connects the states of Rio de Janeiro and São Paulo. In 2021 it announced a fifth system, Firmina, which should be ready for service in 2023, linking the eastern US to Brazil, Uruguay, and Argentina.

Beyond submarine cables, Google has also invested in other types of infrastructure, to which the cables provide increased connectivity. These include its data center near Santiago (Chile), as well as cloud regions in São Paulo (Brazil) and Santiago (Chile). Plans for a third cloud region in LAC, in Mexico, were announced in July 2022. It is also important to note that Google offers various caching solutions, such as Google Global Cache (GGC), which allows ISPs to serve certain Google

1 A fibre pair swap is when a submarine cable provider exchanges a fibre pair on its cable with a fibre pair on a cable operated by another provider, giving both providers more route diversity and redundancy

content from within their own networks. In addition, Google works actively with other participants in the connectivity ecosystem, including through Internet exchange points (IXPs) which play a key role in ensuring that connectivity and interconnection can be facilitated for all stakeholders across the ecosystem, not just the large ones.

Google submarine cable investments are benefiting the connectivity and digital environment in LAC, leading to cumulative incremental gross domestic product (GDP) of USD178 billion between 2017 and 2027, supporting around 740,000 jobs by 2027

Internet services require an established network that can support the amounts of traffic generated by end users, but, at the same time, network investments also create a better environment for digital services to be served. In other words, these investments increase the level of connectivity within the region, bringing a wide range of benefits to countries, both to their businesses and to society as a whole.

The Inter-American Development Bank has highlighted that many of these benefits are linked to education, health and supply/production development;[2] three areas that have a growing dependency on connectivity. Businesses in LAC are forecast to invest heavily in cloud infrastructure in the coming years, taking advantage of improved connectivity in the region.

Together with progressive improvements to domestic networks in the region, including through terrestrial fiber-optic networks and IXPs, Google's submarine cable infrastructure investments are contributing to better, cheaper connectivity in Latin America. For example, Google is currently complementing its Argentinian and Chilean subsea investments by also investing in a cross-Andes fiber connectivity project to link Argentina and Chile. Benefits from subsea and terrestrial fiber projects include a reduction in latency and Internet Protocol (IP) transit prices, and an increase in bandwidth per Internet user. These improvements to the connectivity environment have led to an increase in Internet users in the region, and an increase in data consumption. The positive impacts on Internet penetration and data usage are estimated to support economic growth in terms of both GDP and job creation. Based on econometric modeling developed for this study in partnership with Professor Neil Gandal, we estimate that Google's submarine cable deployments in the region will lead to a cumulative increase in GDP of USD178 billion[3] between 2017 and 2027, compared to a 'counterfactual' scenario in which these cables would not have been deployed. This additional economic output will support the creation of around 740,000 jobs by 2027. In that year, the annual GDP increase will represent 1.08% of projected total GDP in that year in the five countries where Google's cables land.

2 https://publications.iadb.org/publications/spanish/document/Informe-anual-del-Indice-de-Desarrollo-de-la-Banda-Ancha-IDBA-2020-Brecha-digital-en-America-Latina-y-el-Caribe.pdf

3 Value in real 2021 USD, based on World Bank constant 2015 USD GDP series; this converts prices based on official 2015 exchange rates between local currency and USD, then strips out the effect of inflation to obtain values that are comparable over time

Submarine cable infrastructure investments should be encouraged by straightforward, transparent, and supportive regulatory regimes in LAC

The regulatory and policy environment for the deployment of submarine cables is not always clearly defined or easily accessible in LAC countries, although there are differences among the various markets. Industry players have stated that a transparent, consistent licensing regime would facilitate the deployment and maintenance of cables in the region.

An action that could improve the licensing regime would be to document the process for acquiring all the necessary permits, and make this easily accessible. In addition, the regulatory burden involved in securing permits should be limited, and require interaction with one central point of contact rather than various agencies. Furthermore, agencies that grant licenses and permits should have the necessary institutional knowledge of the processes involved.

In addition, cable-protection laws[4] need to be well designed to avoid unintended consequences and to provide added reassurance to those launching cables. Finally, cabotage laws, that is to say laws related to the right to operate ships in particular territories, need to be designed carefully in order to avoid causing additional regulatory burden, ensuring that maintenance and repairs can be carried out as quickly as possible to ensure the ongoing benefits of the cables.

With these improvements put in place, the foreign investments that appear to be generally welcomed in LAC should continue to be made in the region, and as a result both businesses and end users will benefit from better connectivity systems.

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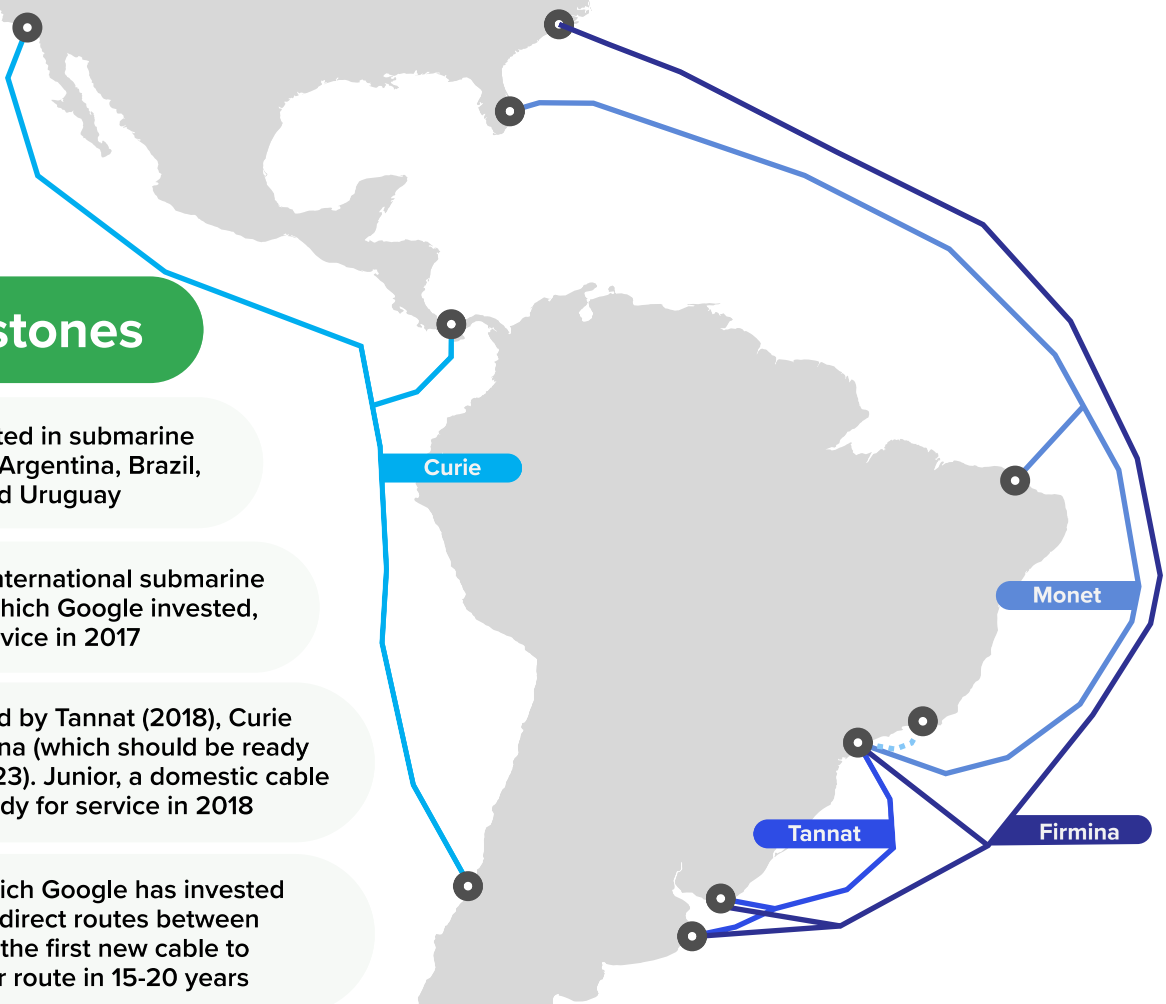
4 For example, such laws exist in Colombia and Uruguay (see https://www.dimar.mil.co/sites/default/files/normatividad/res_02042012.pdf and https://www.convergencialatina.com/Nota-Desarrollo/112061-3-45-Aprueban_un_nuevo_reglamento_para_proteger_cables_submarinos

Google's submarine cable investments in LAC

Submarine cables deployed



Google's Milestones

- Google has invested in submarine cables landing in Argentina, Brazil, Chile, Panama and Uruguay
- Monet, the first international submarine cable in LAC in which Google invested, was ready for service in 2017
- This was followed by Tannat (2018), Curie (2020) and Firmina (which should be ready for service in 2023). Junior, a domestic cable in Brazil, was ready for service in 2018
- The cables in which Google has invested often cover new direct routes between countries, or are the first new cable to cover a particular route in 15-20 years
- **40%** Across the five countries in which these cables land, they have increased international submarine cable capacity potentially accessible by over 40%

Economic Impact

Better connectivity supply unlocks greater demand

for internet access and data consumption, which help increase annual GDP in 2027 by

1.08% or USD30.9 billion

(at 2021 prices)

Between 2017 and 2027, Curie, Monet, Tannat and Firmina will cumulatively unlock

USD178 billion *(at 2021 prices)*

in GDP, supporting the creation of around

740 000 jobs by 2027

1 Introduction

This report discusses the economic impact of Google's submarine cable infrastructure investments in Latin America and the Caribbean (LAC), and was sponsored by Google, although the analysis contained in this document is the sole responsibility of Analysys Mason. The research that underpins this report was conducted between June 2022 and July 2022. We acknowledge the dynamic situation surrounding the world economy and have used the most up-to-date information and database available as of July 2022.

This report focuses on the economic impact of Google's existing and announced submarine cables in the region, on the countries in which they land (Argentina, Brazil, Chile, Panama, and Uruguay). It presents the findings of work carried out by the Analysys Mason team, combining qualitative research on connectivity markets and the regulatory environment in LAC, an econometric model developed to estimate the economic impact of submarine cables in the region, and a series of interviews with industry stakeholders and Google employees. The report also looks at five additional countries which we regard as important hypothetical submarine cable destinations in the region (Colombia, the Dominican Republic, Guatemala, Mexico, and Peru).

In the report, we explain the network infrastructure underpinning the Internet and the investments that Google has made in submarine infrastructure across LAC (Section 2). We then explore the economic impact of these investments (Section 3), in terms of GDP and job creation, as well as other connectivity improvements. Finally, we provide an overview of regulatory best practice (Section 4).

The report includes annexes containing supplementary material:

- Annex A provides provide further detail on the economic impact assessment used to estimate the job and GDP impact of Google's submarine cable investments
- Annex B summarizes the methodology described on Annex A in a question-and-answer (Q&A) format
- Annex C includes a list of submarine cables deployed in the countries of interest.

2 Network infrastructure investment in LAC by Google and others is driven by sustained growth in Internet usage

Submarine cables are an important part of the large, interconnected infrastructure which underpins the Internet around the world. This is certainly the case in the LAC region: the enormous size of some countries and the nature of the terrain make the deployment of terrestrial networks challenging in certain areas, and many large population and economic centers are located in coastal areas. Internet companies such as Google, which provide content, services, and applications over the Internet, are increasingly deploying infrastructure to support their needs globally and regionally, including in LAC. The sustained growth in data usage in the region, including through cloud, feeds the need for more submarine cables, including Firmina, which Google announced in 2021. Other infrastructure plays a part in the overall connectivity, for example microwave and satellite, but these technologies alone do not provide a holistic solution with sufficient scalability to handle traffic requirements.

2.1 End users rely on the interconnected network infrastructure over which Internet services are provided

Access to the Internet has become a key part of the everyday life of consumers and businesses around the world, as it facilitates communication, learning, work, socializing, and entertainment. The Internet itself has continued to evolve rapidly from a technical perspective in recent years, for example with the launch of 5G services and fiber-optic networks. This evolution has been accompanied by the development of new data-heavy and real-time applications and use cases, such as high-definition video services, gaming, and online commerce.

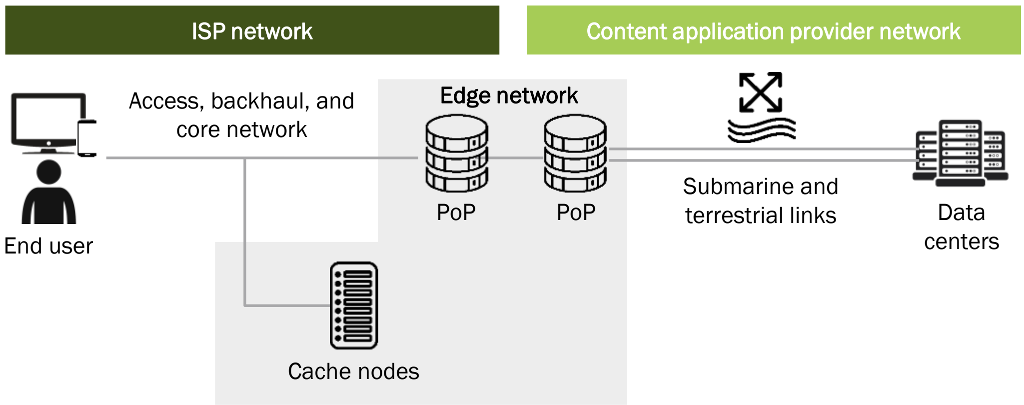
Online content and applications are usually hosted in various data centers around the world. When an end user wants to access this content, or use a particular online service, the necessary data travels from the data center(s) in which it is stored to the end user's device. This will often involve the data being transported across multiple interconnected networks, and through transport links (including both terrestrial and submarine cables) that connect numerous locations around the world.

International links are used alongside peering and caching to increase the efficiency of traffic delivery and improve quality of service

Data from Internet companies such as Google is delivered through international terrestrial and submarine links to points of presence (PoPs) around the world. These PoPs are located in places where multiple Internet companies/content providers and Internet service providers (ISPs) can exchange traffic (typically through a process called 'peering') via public Internet exchange points (IXPs) or direct connections. The ISP then takes the traffic and delivers it to the end user, across its own network (including its core, backhaul, and access networks as required). Whilst international links can be carried over terrestrial networks, submarine cables are often preferred where possible, as they allow easier point-to-point connectivity between two countries that might not share a land border (e.g., the US and Brazil), involving much less complexity than with a terrestrial link across multiple countries. Submarine cables enable the Internet to be truly global, with traffic able to be transported around the world with as little delay as possible.

In order to deliver these services across the Internet, many stakeholders are investing in a complex chain of infrastructure assets, deployed on a massive scale globally and across the value chain, as shown in Figure 2.1.

Figure 2.1: Infrastructure assets that enable content, services, and applications on the Internet [Source: Analysys Mason, 2020]



Value chain element	End user	Access networks	Edge network	Submarine & terrestrial links	Data centers
Description	**End users** access the Internet using applications on devices and initiate data requests across the connectivity value chain	**Access,** backhaul, and core networks provide Internet connectivity to end users via mobile or fixed-line networks	**Edge network** elements serve to bring content closer to end users by serving as efficient points of interconnection (PoPs) and storage of static content (cache nodes)	**Submarine and terrestrial** fiber cables facilitate the transmission of data between data centers and PoPs, which are typically across different geographies	**Data centers** are facilities that store content and process data on a large scale

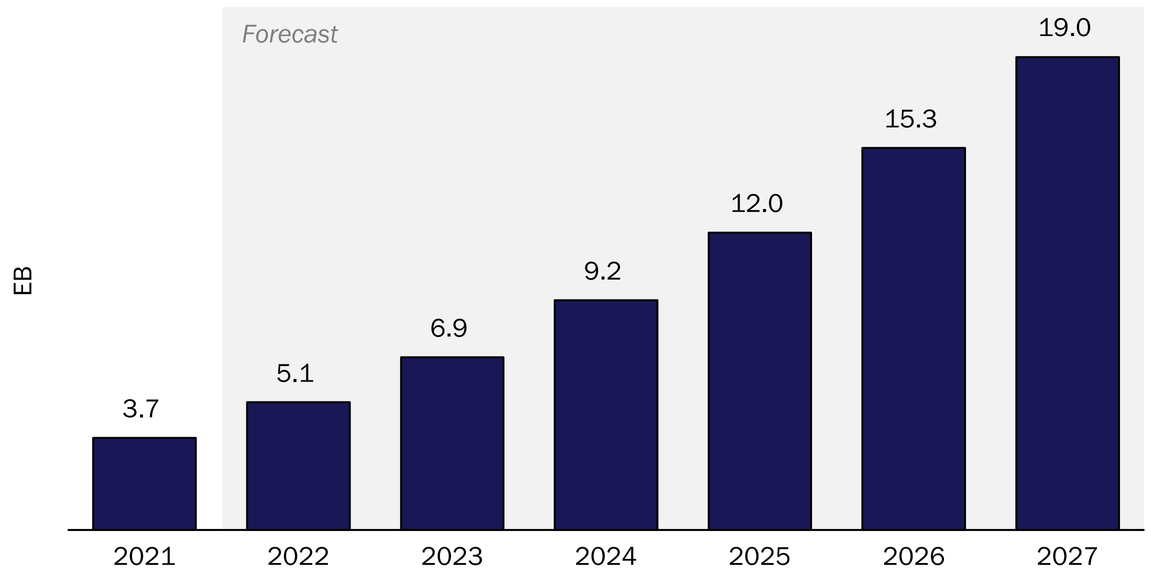
Good international connectivity is essential to allow Internet companies like Google to bring traffic closer to ISPs' domestic networks and peer domestically with them. In many cases, content or data does not need to be delivered around the world each time an end user requests it; it can instead be stored locally in a 'cache'. Caching is used to store popular content such as video closer to the end user in anticipation of demand, thereby reducing the need to constantly transport it from core data centers. This leads to a reduction in cost for both ISPs and Internet companies/content providers, and a reduction in latency (a key measure of the time it takes for content to be requested and served) for end users.

Internet traffic in Latin America will continue growing in the coming years

Internet traffic in Latin America has grown in recent years, as a result of higher levels of penetration of Internet connections and connected devices, including smartphones, as well as increased data usage per user. This growth in data usage is itself the product of several factors, including better network infrastructure, and the development and growing popularity of data-heavy applications. The Covid-19 pandemic has also had a particular impact here, with the rise in home working leading to a major increase in data-heavy activities such as videoconferencing. The impact also stretches beyond the professional sphere, as lockdowns and other pandemic restrictions (e.g. limits on travel and other leisure activities such as shopping, going to the cinema, eating out) meant that people spent more time at home, with much of this time likely to have been filled by online activities such as video streaming.

This trend of increasing data traffic is forecast to continue in the region during the coming years. As an example, Figure 2.2 shows Ericsson's forecast of monthly mobile data traffic in Latin America from 2021 until 2027. This grows from 3.7EB per month in 2021 to 19.0EB per month in 2027, representing a compound annual growth rate (CAGR) of 31.4%.

Figure 2.2: Monthly mobile data consumption forecast in LAC [Source: Ericsson Mobility Report, November 2021]



2.2 Latin American Internet network infrastructure relies heavily on submarine cables

Submarine cables play an important role in Latin America due to the enormous size of some of the countries, and the fact that some types of terrain can be challenging for terrestrial deployment. There are major mountain ranges in the region, as well as significant areas of jungle and rainforest. For example, the Andes are the world's longest mountain range at 8850km, with hundreds of peaks over 4500 meters high, many of which are volcanic. Alongside these mountains, the continent is also home to the Amazon River basin, which has an area of 7 million km², and contains the world's largest rainforest. South America is also where what is generally considered to be the driest place in the world can be found: the Atacama Desert. As a result of this varied and often challenging terrain, and the presence of large population centers in coastal areas, it can be more attractive to deploy subsea infrastructure than to establish certain terrestrial routes.[5] Other technological solutions have their own limitations, including limited capacity and physical constraints.[6]

Submarine cables provide connectivity between countries in Latin America, as well as links to other continents, particularly North America

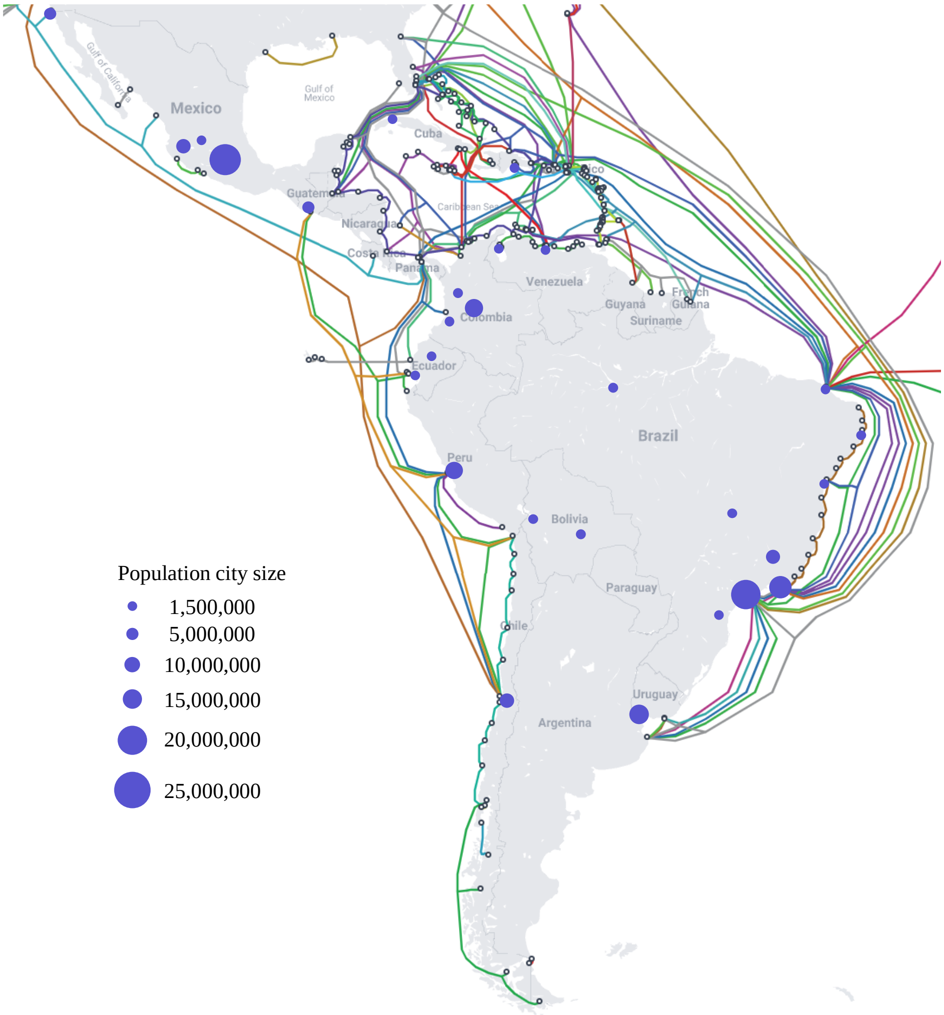
In Latin America, 69 submarine cable systems are currently in service (as illustrated in Figure 2.3 below). A total of 25 international submarine cable systems are currently in operation across the ten countries of focus for this study,[7] with a total design capacity of around 1300Tbit/s and a length of more than 200,000km. These range from smaller, lower-capacity cables deployed in the early 2000s which will now be approaching end of life, to much larger, more-modern systems deployed in recent years. Since 2017, ten new cables have been deployed in the countries of interest, four of these by Internet companies (Google or Meta), directly or through partnerships.

5 For interior connectivity (inland, rather than coastal), fibre will be required, as well as perhaps satellite and microwave connections

6 For example, microwave transmission generally has limited reach and requires line of sight, necessitating the deployment of a relay network. It can also be impacted by environmental constraints, and may have limited penetration through certain obstacles

7 The five countries where cables in which Google has invested land (Argentina, Brazil, Chile, Panama and Uruguay), plus five countries we see as important potential submarine cable destinations in the region (Colombia, the Dominican Republic, Guatemala, Mexico and Peru)

Figure 2.3: Map of submarine cables in Latin America [Source: TeleGeography, Simplemaps, 2022]



International cable systems in LAC can broadly be divided into three main routes:

- LAC to US (Atlantic coast)
- LAC to US (Pacific coast)
- intra-LAC.

A small number of cables follow other intercontinental routes:

- LAC to Europe
- LAC to Africa.

There is currently no direct route linking Latin America to Asia, but a project is under consideration to link Chile to Oceania (Humboldt – see below for more detail).

With 13 cables currently deployed, Brazil is the country in Latin America with the largest number of international submarine cables and associated submarine capacity

Among the countries of interest for this study, Brazil has the largest number of international submarine cable deployments (13, with Firmina currently being deployed in addition to these), as well as the highest design capacity from existing cables (901Tbit/s). At the other end of the scale, Mexico has the lowest level of existing design capacity in international submarine cables (76Tbit/s), but this is likely due to its terrestrial links with the US, and it has two further cables under deployment. In July 2022, Google also announced the deployment of a new cloud region in Mexico (its third in Latin America). According to Google, this will allow local users to "maintain low latency and the highest security, data residency, and compliance standards, including specific data storage requirements".[8]

Uruguay's total international submarine capacity is also on the low side compared to other countries in the study (96Tbit/s), but as well as having a smaller population than many countries in the region, meaning less traffic is likely to be generated, it will also benefit from the future deployment of Firmina adding a further 240Tbit/s (see Section 2.3).

Figure 2.4 sets out a summary of the cables landing in each country of interest, according to TeleGeography. Cables in which Google has invested are shown in bold.

Figure 2.4: Summary of existing international submarine cable connectivity by country of interest [Source: TeleGeography, operator websites, 2022]

Country	Number of cables	Existing cables (ready for service (RFS) date)	Total design capacity[9]
Argentina	6	Bicentenario (2011), Malbec (2021), South America-1 (SAm-1) (2001), South American Crossing (SAC) (2000), **Tannat (2020)**,[10] Unisur (1995)	296Tbit/s
Brazil	13	America Movil Submarine Cable System-1 (AMX-1) (2014), Americas-II (2000), Brusa (2018), Ellalink (2021), Globenet (2000), Malbec (2021), **Monet (2017)**, SAC (2000), SAm-1 (2001), Seabras-1 (2017), South Atlantic Cable System (SACS) (2018), South American Inter Link (SAIL) (2020), **Tannat (2018)**	901Tbit/s
Chile	4	**Curie (2020)**, SAC (2000), SAm-1 (2001), South Pacific Cable System (SPSC)/Mistral (2021)	296Tbit/s

8 https://cloud.google.com/blog/products/infrastructure/announcing-a-new-google-cloud-region-in-mexico

9 This is calculated as the sum of the maximum potential capacity reported on each cable landing in each country. In practice, the design capacity of an individual cable will be shared among users in all countries that it serves

10 Tannat was ready for service in Argentina in December 2020; for the purpose of the impact assessment in this report, we have considered its impact from the start of 2021

Country	Number of cables	Existing cables (ready for service (RFS) date)	Total design capacity[9]
Colombia	8	AMX-1 (2014), ARCOS (2001), Colombia–Florida Subsea Fiber (CFX-1) (2008), Globenet (2000), Maya-1 (2000), Pacific Caribbean Cable System (PCCS) (2015), SAC (2000), SAm-1 (2001)	401Tbit/s
Dominican Republic	6	AMX-1 (2014), Antillas 1 (1997), ARCOS (2001), East–West (2011), Fibralink (2006), SAm-1 (2001)	128Tbit/s
Guatemala	4	AMX-1 (2014), ARCOS (2001), SAm-1 (2001), SPSC/Mistral (2021)	248Tbit/s
Mexico	4	AMX-1 (2014), ARCOS (2001), Maya-1 (2000), Pan-American Crossing (PAC) (2000)	76Tbit/s
Panama	6	ARCOS (2001), **Curie (2020)**, Maya-1 (2000), PAC (2000), PCCS (2015), SAC (2000)	300Tbit/s
Peru	3	SAC (2000), SAm-1 (2001), SPSC/Mistral (2021)	224Tbit/s
Uruguay	3	Bicentenario (2011), **Tannat (2018)**, Unisur (1995)	96Tbit/s

Five further international submarine cables are set to be ready for service in Latin America by 2025

In addition to the cable systems that are already in service, the deployment of a further five international cables has been announced in the region (as shown in Figure 2.5). These will total a further length of approximately 24,000km, and at least 588Tbit/s in additional design capacity.[11]

Figure 2.5: List of confirmed future cables in countries of interest [Source: TeleGeography, operator websites, 2022]

Cable	Provider	Route	Length	RFS date	Design capacity	Landing points
GigNet-1[12]	GigNet	LAC–US (Atlantic)	1104km	2022	24Tbit/s	Mexico, US
Firmina	Google	LAC–US (Atlantic)	14,517km	2023	240Tbit/s (approx.)[13]	Argentina, Brazil, Uruguay, US
Boriken Submarine Cable System (BSCS)	Blackburn Technologies	Intra-LAC	670km	2024	Not announced	Dominican Republic, Puerto Rico, US Virgin Islands
Caribbean Express (CX)[14]	Ocean Networks	LAC–US (Atlantic)	3472km	2025	324Tbit/s	Colombia, Mexico, Panama, US

11 Only two of the five cables have had capacity announced in Tbit/s, so the actual value should ultimately be much higher than this

12 https://gignet.mx/company/marine-survey-completed-for-the-gignet-1-subsea-cable-system/

13 https://docs.fcc.gov/public/attachments/DOC-384367A1.pdf

14 https://www.oceannetworks.com/copy-of-projects

Cable	Provider	Route	Length	RFS date	Design capacity	Landing points
Carnival Submarine Network-1 (CSN-1)[15]	Telconet	LAC–US (Atlantic)[16]	4500km	2025	Not announced	Colombia, Ecuador, Panama, US

As well as the cables listed above, several new cables are reportedly under consideration or in the early stages of planning:

- The Argentine, Chilean, and Brazilian subsidiaries of Silica Networks have announced a joint project to commence a feasibility study of a submarine fiber-optic cable network to the Antarctic continent.[17]
- The Brazilian and Guyanese governments signed a memorandum of understanding in 2020 on studying the technical feasibility of a fiber-optic link between the two countries, as part of their shared aim of improving connectivity in the Amazon region.[18]
- In late 2018, Hemisphere Cable Company (HCC) announced its plans to deploy the WASACE 1 submarine cable, to connect Fortaleza (Brazil), the Canary Islands, and Seixal (Portugal), with additional branches to Cape Verde, Madeira (Portugal), and Casablanca (Morocco).[19] The cable was supposed to be ready for service in 2021, but no recent updates have been provided.
- Chile is exploring the possibility of deploying the Humboldt Cable System, which would connect the country with Australia, becoming the first cable to connect Latin America with Asia–Pacific and Oceania. The initial design of the cable includes between four and eight fiber pairs, with a transmission capacity of 10Tbit/s to 20Tbit/s, and the system could be ready for service in early 2025.[20]

15 https://web.asn.com/press-release/2022-03-28-CSN1.html

16 CSN-1 will also have a Pacific branch between Panama and Ecuador, but connects to the US in Florida and so has been classed as Atlantic

17 https://www.commsupdate.com/articles/2021/07/23/cable-compendium-a-guide-to-the-weeks-submarine-and-terrestrial-developments

18 https://www.commsupdate.com/articles/2020/12/04/cable-compendium-a-guide-to-the-weeks-submarine-and-terrestrial-developments

19 https://www.commsupdate.com/articles/2018/12/07/cable-compendium-a-guide-to-the-weeks-submarine-and-terrestrial-developments

20 https://www.submarinenetworks.com/en/systems/trans-pacific/humboldt-cable/chile-selects-h2-cable-to-develop-humboldt-cable-system and https://www.commsupdate.com/articles/2022/01/07/cable-compendium-a-guide-to-the-weeks-submarine-and-terrestrial-developments

2.3 Google is investing in submarine cable infrastructure in Latin America

The key driver for Google in deciding when and where to invest in a new cable is its projected capacity requirements for future years, covering all types of traffic (such as cloud as well as Google content), supported by its needs for increased redundancy and reduced latency.

As Google's capacity requirements are driven in part by demand from Google Cloud customers, other factors are key to the impact that new connectivity projects can have, such as the readiness of businesses in the region to take advantage of cloud and online services. Recent events and publications have underlined Google's commitment to LAC and the importance of digital technology to the growth of the LAC economy.[21]

Google has been at the forefront of a fresh wave of submarine cable infrastructure investments in the region

Google initiated new investments in international submarine infrastructure in Latin America and therefore increased connectivity in some countries, after a period during which very limited investments had been made. With the exception of Bicentenario (a small cable crossing Rio de la Plata to link Argentina and Uruguay, ready for service in 2013), in three of the five Latin American countries where Google spearheaded a submarine cable landing (Argentina, Chile, and Uruguay), Google's was the first major international cable to be deployed in over 15 years. In the remaining two countries (Brazil and Panama) it was the second. In all these countries, with the exception of Uruguay, investment from Google has been followed by new deployments from other providers.

***Closer look*: Google is part of a recent drive to upgrade and enhance submarine cables landing in Argentina**

Currently there are six international submarine cables serving Argentina. Unisur was launched back in 1995, followed by South American Crossing (SAC) in 2000 and South America-1 (Sam-1) in 2001. The only deployment in the following 17 years was Bicentenario, a small cable crossing the Rio de la Plata to link Argentina and Uruguay.[22]

The first submarine cable in Argentina in which Google invested was launched in 2020, with the deployment of Tannat, linking the country to Uruguay and Brazil. With a design capacity of 90Tbit/s,[23] Tannat almost doubled the total submarine cable design capacity serving Argentina at that point in time.[24]

Following this first deployment of a major cable in many years, Meta and GlobeNet launched Malbec in 2021, providing a further 108Tbit/s between Argentina and Brazil. Google has subsequently announced the deployment of Firmina, which is expected to be ready for service in 2023, and will link Argentina to Uruguay, Brazil, and the US.

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21 See, for example, https://blog.google/around-the-globe/google-latin-america/our-commitment-latam-digital-future/ and https://blog.google/outreach-initiatives/public-policy/a-100-billion-opportunity-to-boost-digital-exports-in-latin-america/

22 https://www.telegeography.com/products/global-bandwidth-research-service/data/submarine-cable-profiles/bicentenario/index.html

23 https://latam.googleblog.com/2015/11/tannat-un-cable-nuevo-para-america-del-sur.html

24 https://www.telegeography.com/products/global-bandwidth-research-service/data/submarine-cable-profiles/tannat/index.html

Google's infrastructure investments help to bring services to end users (Gmail, YouTube, Android) and Google Cloud customers around the world

Google's network infrastructure investments help with the transport of traffic between different Google data centers, as well as content delivery to ISPs and Internet users (for example, Google content such as YouTube, Google Cloud, Google Docs, Gmail, Google Meet, Google Maps, etc.). There is a large degree of data replication between data centers, and then regional cloud infrastructure is used to serve customers locally. Specifically in LAC, Google currently has two cloud regions. The first was launched in São Paulo (Brazil) in 2017, and the second in Santiago (Chile) in 2021. As described earlier, in July 2022 Google announced plans for a third cloud region in Latin America, in Mexico. It is also important to note that Google offers various caching solutions, such as Google Global Cache (GGC), which allows ISPs to serve certain Google content from within their own networks.[25] This brings the content closer to users, thereby reducing latency and increasing quality of service.

"It's essential to have a good relationship/partnership with the [Internet companies] that are investing in Latin America [...] we have found a way to manage the relationship to be beneficial for our company"

"You develop a certain relationship on one side, on the other a business model confidence"

"[Internet companies] are not competitors, so the matching of the joint force tends to be smoother than with a competitor, when you can do similar things but at the end you are competing head-to-head. Here that dimension is not exactly there, which somehow helps"

Global submarine cable operator

Due to the timelines involved for deployment, new submarine cables have to be planned, designed, and approved well ahead of when the capacity they will offer is required. In general, these projects usually take between three and five years, depending on complexity.

Google has redundancy in its network through investment in multiple cable systems landing in LAC. Some of these are owned by Google, while others are owned by partner operators.[26] Google's investments allow other companies with whom it partners to benefit from the use of its cables. The exchange (or 'swap') of fiber pairs provides more geographical diversity for both parties' routes. Therefore, if there were to be a problem on one particular cable/route, traffic could be rerouted via an alternative route (ideally one of several options), and so the impact on quality of service should be limited.

Traditional submarine cable operators tend to see Google as a potential partner on submarine cable projects. Some of these players welcome the opportunity to co-invest in new cables with Google, which is seen as bringing both significant financial capacity as well as recognized engineering and operational expertise. This can be particularly relevant for routes that would not be commercially viable for traditional providers if they were deploying them alone, as in these cases deployment in

25 https://support.google.com/interconnect/answer/9058809?hl=en

26 https://www.submarinenetworks.com/en/systems/brazil-us/curie/sparkle-acquires-a-fiber-pair-on-google-s-curie-cable-system

partnership with Internet companies could provide an alternative to requiring the use of public funds, or simply not deploying at all and making use of less direct routes.

Three international submarine cables in which Google has invested have been deployed in Latin America, as well as a domestic one in Brazil, and Firmina was announced in 2021

The first international submarine cable in Latin America in which Google invested, Monet, was ready for service in 2017. Since then, three more cables in which Google has invested have been launched, and in 2021 a fifth system, Firmina, was announced, which should be ready for service in 2023, linking the eastern US to Brazil, Uruguay, and Argentina.

Existing systems include:

- **Monet**, ready for service in December 2017, which connects the state of São Paulo and Fortaleza in Brazil with Florida in the US. It spans a distance of 10,556km and has a design capacity of 64Tbit/s. It was launched as part of a consortium alongside Algar Telecom, Angola Cables, and Antel Uruguay.
- **Tannat**, ready for service in the first quarter of 2018, again alongside Antel Uruguay. It connects the state of São Paulo with Maldonado in Uruguay and Las Toninas in Argentina. It covers a distance of 2000km and has a design capacity of 90Tbit/s.
- **Curie** connects Valparaíso in Chile with California in the US, and also includes a branch providing a connection to Panama. The Curie system has a total length of 10,476km and a design capacity of 72Tbit/s. It was deployed by Google as the sole investor, and provides significant connectivity to Google's data center near Santiago (Chile).

In addition to international submarine cables, **Junior**, a domestic submarine cable in Brazil linking the states of São Paulo and Rio de Janeiro, was deployed in 2018. Junior serves as an extension of international connectivity arriving in São Paulo, which hosts the landing stations of both Monet and Tannat.

> ***Closer look*: the role of data centers**
>
> Data centers play a key role in the deployment of both terrestrial and submarine telecoms infrastructure. While there is something of a "chicken and egg" situation in terms of whether submarine cables or data centers are deployed first, submarine cables are often ultimately used to provide connectivity between data centers.
>
> For example, this is the case in Chile, where Curie connects Google's data center near Santiago with its fleet of data centers in North America (e.g., in Nevada). Because Google also has terrestrial paths across Chile and Argentina, traffic can also take the Atlantic route to the US if required.

Firmina, with a design capacity of 240Tbit/s, will be the longest cable in existence that can run entirely from a single power source at one end of the cable, if its other power source becomes temporarily unavailable, which should increase its resilience and reliability.[27] Firmina will increase the capacity available to Google on its own infrastructure along the Atlantic coast, and reinforce

27 https://cloud.google.com/blog/products/infrastructure/announcing-the-firmina-subsea-cable

existing routes through the continent, including to Google's data center in Chile. Brazil will then be connected by a branch north to South Carolina, providing it with direct connectivity to another of Google's major data centers in the area.

***Case study:* the benefits of a new landing station**

Submarine cable landing stations are an important building block in wider digital connectivity structures.

Firmina will be the first submarine cable to have a landing station in South Carolina. Often the deployment of the first submarine cable, and associated infrastructure, will then lead to the deployment of further cables, thereby significantly increasing connectivity for the region/country. This already appears to be the case in South Carolina, as the landing station that will house Firmina will have space for additional cables. When multiple cables use the same landing station this benefits each provider, as it allows costs to be shared, enables traffic to be exchanged across cables, and offers the opportunity to exchange fiber pairs in different cables, thus providing greater redundancy. Furthermore, Google often leases or licenses the necessary infrastructure and services to operate submarine cables, which directly contributes to local economic development by creating opportunities for local companies to act as operator partners.

While this report focuses on the benefits to Latin America, which are large as it is currently under-connected, communities in which a cable lands (including South Carolina in this case) benefit from broader clustering dynamics associated with digital infrastructure. The development of strong, resilient networks between countries can promote integration and cohesion between markets. Increased digital connectivity can help to reduce barriers and impediments to digital trade, which can lead to an increase in cross-border commerce. The deployment of cable landing stations can also lead to the establishment of digital clusters, as landing stations with multiple cables are natural places for the deployment of IXPs and data centers etc., which may in turn help to encourage other digital companies to set up operations in the area, bringing associated economic benefits for the region.

Outside Latin America, Marseille (France) provides a good illustration of how many cables can follow a first one. The first of Marseille's cables was launched in 2005, followed by five more before the end of 2011. Another cable was deployed in 2017, and now a further wave of six cables is being deployed between 2022 and 2025. Once all have been launched, total design capacity serving Marseille will exceed 1120Tbit/s, and it will have cables linking it to landing stations in countries as diverse as South Africa, India, China, Singapore, and Malaysia. The presence of all of these cables has helped Marseille to become a European interconnection hub. Beyond submarine cables, it now has three IXPs (plus another nearby in Aix-en-Provence), as well as 13 data centers (operated by a range of providers including Interxion, Colt, and Lumen).[28]

Google has not announced any investments in further cables in the LAC region, though with traffic growth anticipated to continue it is likely that additional subsea infrastructure deployment could be required in the future at some point. With the extra capacity that Firmina will bring to the east side of Latin America, more data centers could also be deployed.

28 https://www.Internetexchangemap.com and https://www.cloudscene.com

3 Google's submarine cables are improving connectivity in LAC, driving an estimated USD178 billion in additional GDP by 2027

Google's investments in submarine infrastructure support the delivery of its content to end users, by improving service performance and reliability. More broadly, Google's investments in LAC aim to improve the overall performance, resilience, and cost-effectiveness of Internet infrastructure. Although it tends to only use its self-deployed capacity for itself, this frees up capacity on other cables for others, which increases the overall supply in the market and leads to better connectivity outcomes in the region. These include an increase in the number of Internet users, greater data usage per user, and facilitation of new, richer applications for both consumers and businesses. Increased numbers of users and greater data usage contribute to economic growth and the creation of jobs, a relationship that has been confirmed in numerous studies.[29] For example, the World Bank highlighted in 2009 that broadband has "considerable economic impact at all levels of individuals, firms, and communities", with "individuals increasingly [using] broadband to acquire knowledge and skills to increase their employment opportunities". Our analysis as part of this study validates these findings for LAC.

In order to demonstrate this, and to reflect the specificities of the Latin America region, we carried out our own econometric modeling in partnership with Professor Neil Gandal at Tel Aviv University. Google is continuing to invest in Latin America, with Firmina expected to be ready for service in 2023. Between 2017 and 2027, we estimate that Google's network investments will have supported the creation of up to 740,000 jobs throughout the region and generated up to USD178 billion[30] in additional GDP (USD31 billion in 2027 alone, which represents 1.08% of projected GDP in that year, including Google's cables, in the five countries in which Google cables land).

This section details how Google's investments in submarine cables have a positive impact on the connectivity ecosystem and digital environment in Latin America, and how this translates into economic benefits in the form of jobs and GDP growth. It starts by providing qualitative examples of how increased levels of connectivity can bring benefits to countries, before presenting the estimated positive impact of Google's submarine cable infrastructure on the digital environment in

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29 Qiang/Rossotto, 'Economic impacts of broadband', 2009, see: https://documents1.worldbank.org/curated/en/645821468337815208/pdf/487910PUB0EPI1101Official0Use0Only1.pdf

Katz/Jung, 'Collaborative digital regulation: a much – needed approach to achieving growth of the digital economy', 2022, see: https://www.itu.int/dms_pub/itu-s/opb/jnl/S-JNL-VOL3.ISSUE1-2022-A01-PDF-E.pdf

Deloitte/GSMA, 'What is the Impact of Mobile Telephony on Economic Growth', 2012; see: https://www.gsma.com/publicpolicy/wp-content/uploads/2012/11/gsma-deloitte-impact-mobile-telephony-economic-growth.pdf

30 All GDP values are provided in real 2021 USD, based on World Bank constant 2015 USD GDP series; this converts prices based on official 2015 exchange rates between local currency and USD, then strips out the effect of inflation to obtain values that are comparable over time

Latin America. It concludes by explaining the estimated economic impact of Google's submarine cable infrastructure in the region.

3.1 Increased levels of connectivity can bring a wide range of benefits to countries, both to businesses and society as a whole

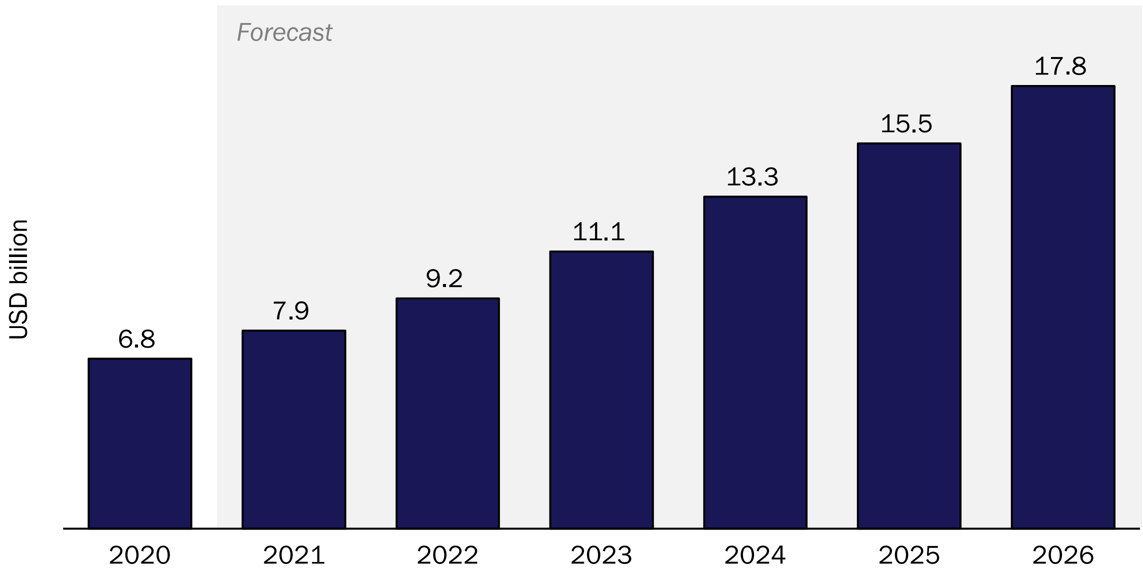
Businesses in Latin America are forecast to invest heavily in cloud infrastructure in coming years, taking advantage of improved connectivity in the region

As connectivity in a region improves, business and governments are able to advance further through the process of "digitalization". More and more, they are able to adopt new digital services and integrate digital technology in their day-to-day processes, allowing them to collect, store, and analyze increasingly large amounts of data. Traditional information technology (IT) infrastructure deployed by businesses and governments generally uses servers located on the premises, and systems that do not usually provide the scalability and cost efficiency that is now required. As a consequence, businesses and governments have started to move their data and applications to the cloud. This can either be *private* cloud infrastructure, where the organization operates the cloud infrastructure itself for its own dedicated use, or *public* cloud infrastructure, where third-party cloud service providers (e.g. Google) deploy and operate the infrastructure, and deliver the services to their customers over the Internet. It is also possible to have *hybrid* cloud infrastructure, combining both public and private cloud. The deployment of cloud infrastructure, and the realization of the associated benefits, is contingent on having sufficient connectivity in a region.

> *"Businesses in Latin America are still in the early stages of cloud adoption. Concerns remain around cybersecurity, which are holding back take-up"*
>
> LAC-focused operator group

Take-up of cloud services is expected to increase significantly in Latin America in the coming years. As an example of the current level of adoption, Analysys Mason Research reports over 25 million software-as-a-service (SaaS) users in Latin America at the end of 2021. Figure 3.1 shows the forecast total spend on public cloud infrastructure in Latin America from 2020 to 2026. The increase from USD6.8 billion in 2020 to USD17.8 billion in 2026 represents a CAGR of 17%.

Figure 3.1: Forecast public cloud spend in Latin America [Source: Analysys Mason Research, 2022][31]



The adoption of cloud infrastructure offers numerous benefits for businesses and governments, as highlighted by Google in its *Digital Sprinters* report.[32] Users of public cloud infrastructure can pay for resources as part of a pay-as-you-go model, rather than having to make capital-intensive up-front investments in infrastructure. As a result of improving the accessibility, affordability, and capacity of computing resources, barriers to entry are reduced for new businesses. This is particularly the case for small-and medium-sized enterprises (SMEs), as it enables them to use resources that they were previously unlikely to have been able to afford, due to the up-front investments required. A positive consequence of this is increased innovation, as it supports the deployment of new products and services.

Increased broadband take-up and usage brings a range of benefits to societies as a whole

Increased connectivity in a region generally leads to higher broadband penetration, and growth in data consumption among existing users (see Section 3.2 for detailed analysis of the impact of Google's submarine cables on these metrics in Latin America). The Inter-American Development Bank has published a report on the development of broadband in Latin America, which highlights a series of benefits that greater broadband penetration can bring to a region.[33]

31 "Cloud spend" refers to the sum of SaaS, infrastructure-as-a-service (IaaS) and platform-as-a-service (PaaS) retail revenue accrued to cloud service providers and telecoms operators. Data published in June 2022, based on historical data up to Q2 2021

32 https://blog.google/documents/94/The_Digital_Sprinters_FINAL.pdf

33 https://publications.iadb.org/publications/spanish/document/Informe-anual-del-Indice-de-Desarrollo-de-la-Banda-Ancha-IDBA-2020-Brecha-digital-en-America-Latina-y-el-Caribe.pdf

At a high level, according to the report, education, health, and supply/production development are three areas that have a growing dependency on connectivity:

- With respect to **education**, increased broadband take-up helps families to use the Internet to communicate with educational centers, and makes schools and training centers more locally accessible for the entire educational community.
- In **health**, use of the Internet is a key element in improving management, optimizing efficiency in the use of resources, and improving control over health expenditure, and therefore it allows better services to be offered to society.
- In the **industrial** sector, particularly among SMEs, the use of broadband services leads to growth and improved management/dealings in national and international markets. More generally, businesses are able to increase their productivity, as Internet use allows them to promote innovation and entrepreneurship, as well as to expand their existing lines of business. The working day can also be reduced, due to the increased efficiency in carrying out tasks offered by improved connectivity, and the number of journeys made by employees will be reduced if they are able to work from home.

The report also highlights a series of intangible socioeconomic benefits of increased broadband penetration. These include greater transparency in government processes, increased sharing of cultural knowledge, a reduction in crime and violence as a result of the reduction of poverty and improved security systems, increased competition as a result of access to global markets, and increased tax revenue from the creation of new businesses.

3.2 Google's submarine cable infrastructure investments are helping to improve connectivity in Latin America, bringing a series of benefits to the digital environment

As described in Section 2.3, Google's investments in new submarine cables have increased the supply of international bandwidth to five countries in Latin America: Argentina, Brazil, Chile, Panama, and Uruguay. In this subsection we show how this increased supply leads to reduced latency, as well as lower prices for buyers of international bandwidth, which in turn leads to higher Internet bandwidth per user. These connectivity enhancements to the digital environment improve the quality of the experience enjoyed by Internet users, and stimulate use cases which can be more data-heavy or require lower levels of latency, such as cloud services, videoconferencing, high-definition video services, and certain types of transaction services.

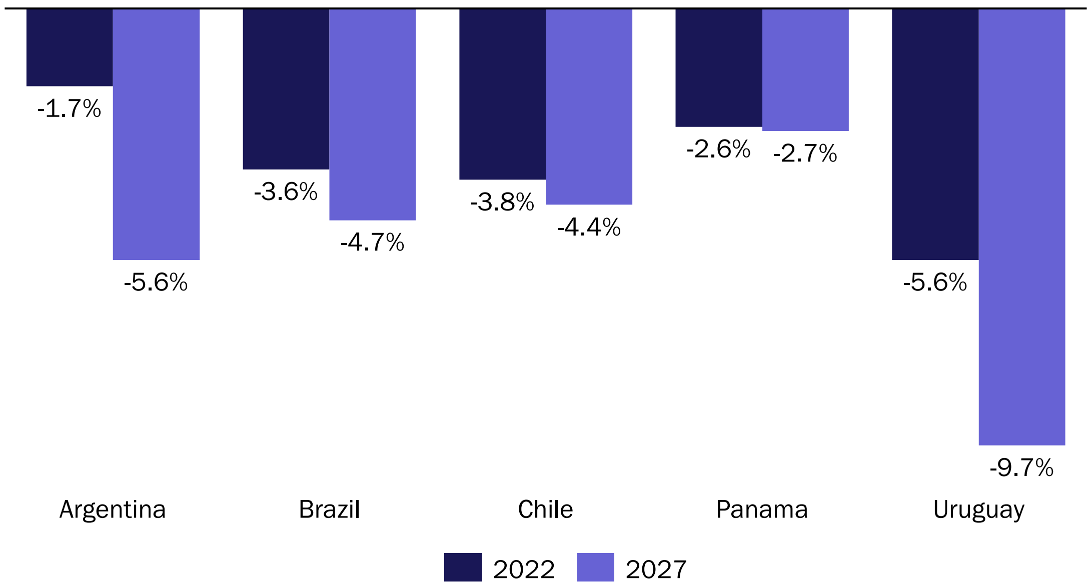
These benefits then lead to positive connectivity outcomes such as an increase in Internet users and growth in data traffic. This is supported by the econometric modeling that we have undertaken for this report, which demonstrates a strong statistical link between the deployment of submarine cables and an increase in both Internet penetration and data traffic in the countries where the cables have landing stations. Further details on the modeling methodology and econometric equations can be found in Annex A.

Google's submarine cable investments have led to a reduction in latency and IP transit prices, and an increase in bandwidth per Internet user

Our modeling demonstrates that submarine cables have a measurable, statistically significant impact on connectivity metrics including latency, IP transit prices, and bandwidth. In this section we show the magnitude of these impacts as estimated by our model. They are significant and in line with work we have carried out in other regions globally. Google's cables have the greatest impact in countries like Uruguay, where they represent a larger proportion of installed capacity, and the lowest impact (in relative terms) in countries like Brazil or Panama that have many other cables.

Submarine cables in Latin America are having a measurable impact on the latency experienced by end users. For the countries where cables in which Google has invested land, the impact of these cables in 2022 is already material; by 2027, once existing cables and Firmina are well established, the impact on latency will be even greater, ranging from a 2.7% reduction in Panama to a 9.7% reduction in Uruguay. This is shown in Figure 3.2.

Figure 3.2: Estimated impact of Google submarine cables on average latency in 2022 and 2027 [Source: Analysys Mason, 2022]



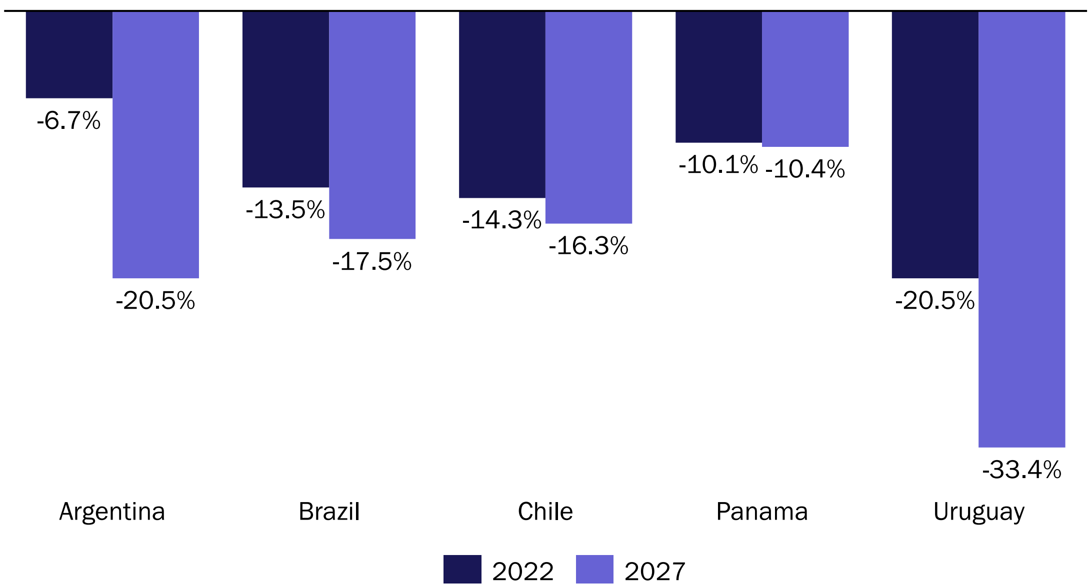
This impact on latency is a combination of direct and indirect effects. By using their own submarine cables, Internet companies such as Google can provide the most direct or optimal links between their own data centers and ISPs' networks. They also take their own traffic away from cables operated by other providers, thereby reducing the potential for congestion on these other cables. Furthermore, better international connectivity in a given country helps to stimulate the deployment of regional content delivery networks (CDNs) or cloud regions, which means that more content is stored directly in the country itself. This permits a more dynamic onshore peering market between Google, other Internet companies, and ISPs, and so leads to a higher-quality experience for Internet users in the country. These cloud services and CDNs are supported by submarine cables, as the cables are required to keep the content/data refreshed and up to date. Without sufficient connectivity, it would not make sense to launch a cloud region or CDN in a country, as the content could not be refreshed easily.

> *"Latency can be a differentiating factor for ISPs when they are looking to contract a wholesale internet service"*
>
> LAC-focused operator

Submarine cables also have a statistically significant impact on prices, in the form of lower IP transit prices. Even though Google generally uses its own cables exclusively for serving its own traffic, deployment of these cables has an indirect impact on the wider international connectivity market. If Google had not deployed the cables, it would be relying more on the capacity of other submarine cables, operated by traditional submarine cable providers, hypothetically constraining supply, and therefore leading to degraded quality or higher prices. Because Google moved much of its own demand to its own cables, this has released capacity on commercial cables for others to use. This puts downward pressure on prices, because the traditional commercial cable operators want to sell this capacity and have very low marginal costs, since nearly all of their own costs are sunk. These reduced costs ultimately benefit end users, including small businesses and consumers in the LAC region whose connectivity depends in part on IP transit costs.

As shown in Figure 3.3, which compares Google cables (including Firmina) to a hypothetical situation in which Google had not deployed any submarine infrastructure, the impact on IP transit prices ranges from a decrease of 10.4% in Panama to 33.4% in Uruguay in 2027.

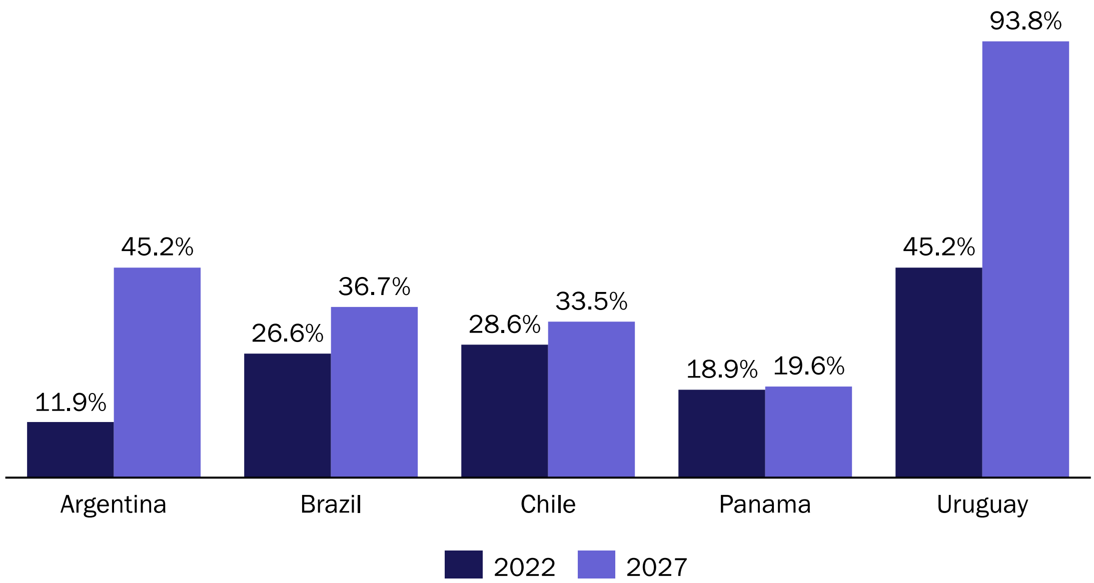
Figure 3.3: Estimated impact of Google's submarine cables on IP transit prices in 2022 and 2027 [Source: Analysys Mason, 2022]



As is the case with all technical costs in telecoms, when fulfilling their international bandwidth requirements, ISPs have a revenue constraint on the costs that they can incur. This spend is used for purchasing IP transit, as well as route-specific bandwidth leases. The decrease in IP transit prices described above, as a result of an increase in supply, means that ISPs can provision higher capacity, in order to carry more traffic with the same budget. As service prices fall, larger or even unlimited buckets of data can be sold. ISPs can also use a wider variety of routes to increase the resilience, redundancy, and reliability of their services. Overall, this leads to more users and higher usage.

This ability to transport more traffic through a greater variety of routes means that levels of bandwidth per Internet user are higher than they would have been without the deployment of Google's submarine cables. As a result, Internet users are enjoying faster download speeds and a better quality of experience than they would otherwise have done. Figure 3.4 illustrates the country-by-country impact of Google's submarine infrastructure investments on bandwidth per user, in 2022 and 2027. The impact in 2027 ranges from an increase in bandwidth per user of 19.6% in Panama to a near doubling (+93.8%) in Uruguay.

Figure 3.4: Estimated impact of Google's submarine cable on bandwidth per user in 2022 and 2027 [Source: Analysys Mason, 2022]



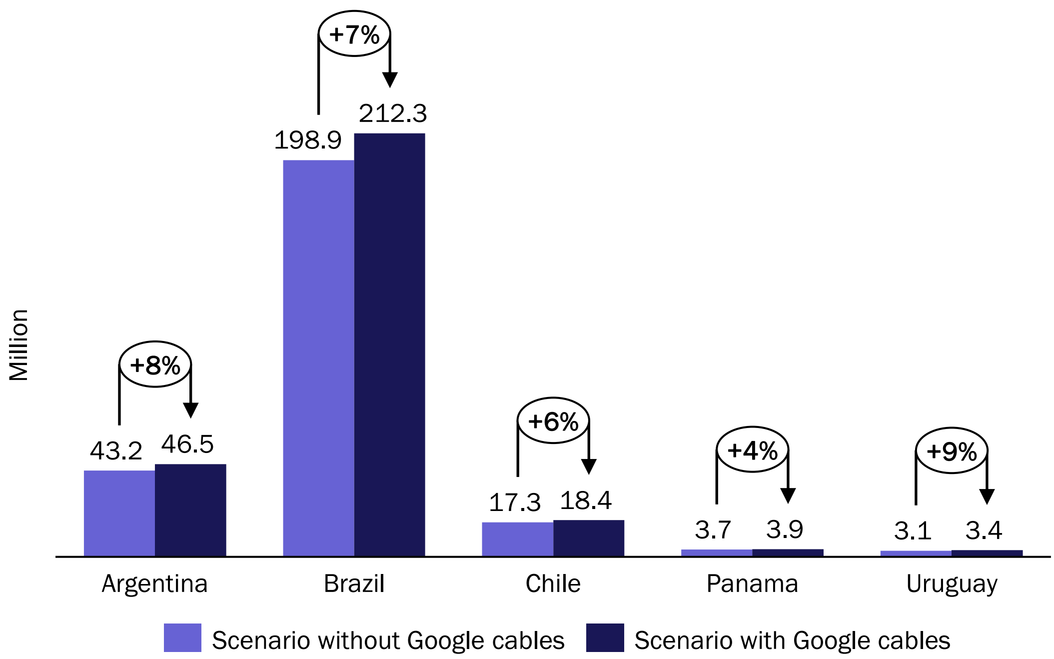
These improvements to the connectivity environment have led to an increase in Internet users in the region, as well as growth in data consumption

The improvements to the connectivity ecosystem described above show how more submarine cables lead to a more plentiful, cheaper, and higher-quality supply of connectivity. In turn, this means that end users (both individuals and businesses) are enjoying better value from their Internet usage. Quality of experience for users from existing services is improved, and new use cases that need lower latency and/or greater international bandwidth can emerge and flourish. This can then support a virtuous circle in which more consumers are willing to pay for (better) Internet access, leading to higher Internet penetration and more Internet traffic per user.

The link between better connectivity from submarine cables and an increase in Internet penetration is supported by our econometric modeling: there is a positive association between lower IP transit prices, low levels of latency, and high availability of bandwidth on the one hand, and an increase in Internet penetration on the other.

These effects are primarily indirect, as of course Google does not connect people directly to the Internet at scale. They are significant, however: Figure 3.5 shows that, by 2027, an estimated additional 18.2 million people will be online as a result of Google's submarine cable investments, including 13.4 million in Brazil.

Figure 3.5: Number of mobile Internet users per country in 2027, with and without Google's submarine cable deployments [Source: Analysys Mason, 2022]

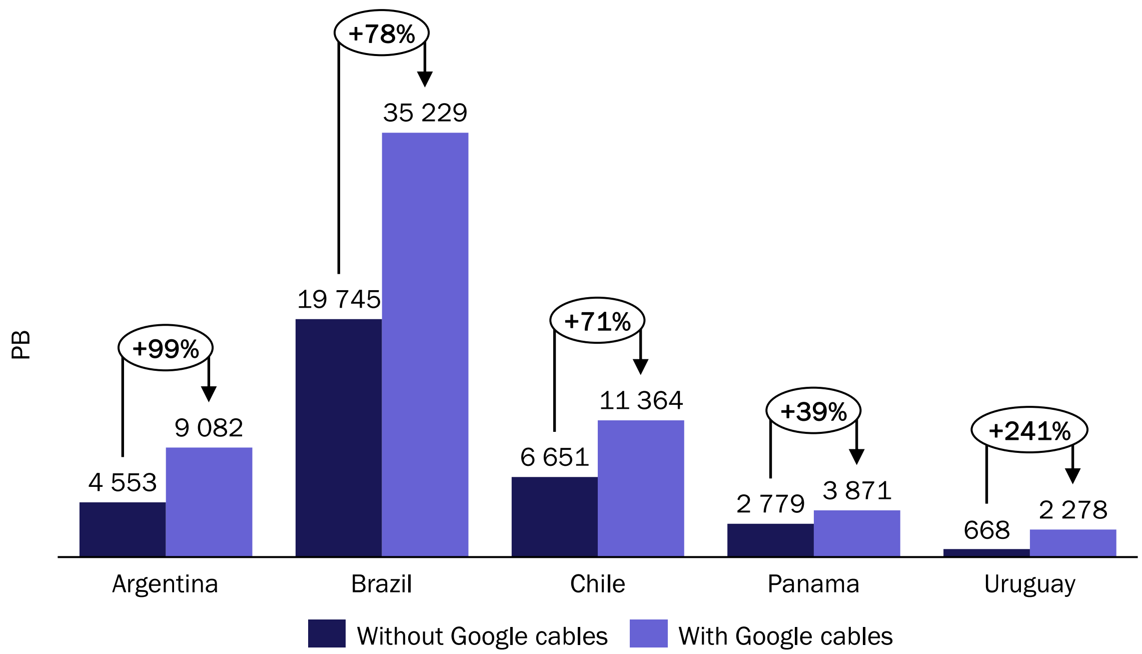


In addition to an increase in the number of Internet users, our analysis and econometric modeling also shows a strong relationship between high availability of bandwidth and mobile data usage.[34] This is in line with what would be expected: an increase in available bandwidth enables and incentivizes increases in demand.

As shown in Figure 3.6, the impact of Google's submarine cable investments on total mobile data traffic across the five countries reaches over 27,000PB in 2027, including over 15,000PB in Brazil. The cumulative impact of Google's investments on total mobile data traffic from 2017 (when Google's first cable was deployed) until 2027 is forecast to be an increase of over 107,000PB.

34 Defined here as mobile traffic per subscriber identity module (SIM) – many Internet users in the LAC region are 'mobile-first' or indeed only access the Internet through mobile networks, despite gradual progress in fiber network deployment, as highlighted in a 2020 article by the Mobile Growth Association: https://mobilegrowthassociation.com/mobile-usage-in-latam-a-breakdown-of-habits-by-country/

Figure 3.6: Mobile data traffic per country in 2027, with and without Google's submarine cable deployments [Source: Analysys Mason, 2022]



3.2.2 Greater demand for connectivity driven by Google's submarine cables will create over USD177 billion in cumulative GDP impact by 2027, supporting 740,000 jobs

Increased usage of the Internet by both individuals and businesses across various sectors is generally understood to be associated with an increase in economic activity. Using an endogenous growth model, we found a strong association between an increase in mobile data usage and higher GDP per capita: that is, a doubling of mobile data usage could result in a 0.75% increase in real GDP growth per capita (see Annex A), an effect that compounds over time through sustained higher annual growth rates.

On this basis, we estimate that the increase in Internet usage linked to Google's submarine cable investments in Latin America, as detailed above, will have contributed to a cumulative increase in GDP of approximately USD178 billion between 2017 and 2027 in the five countries where the cables land, as shown in Figure 3.7, which provides a breakdown by country.

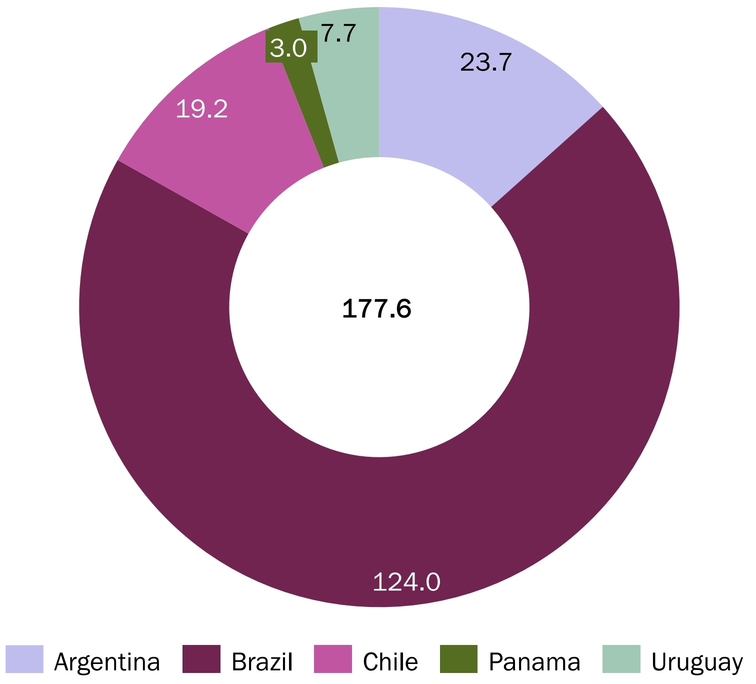


Figure 3.7: Cumulative GDP impact of Google's submarine cable deployments, 2017 to 2027 (real 2021 USD billion) [Source: Analysys Mason, 2022]

Just in 2027, the increase in annual GDP is around USD31 billion (which represents 1.08% of projected GDP in that year, including Google's cables). Figure 3.8 shows the GDP impact in 2027, split by country.

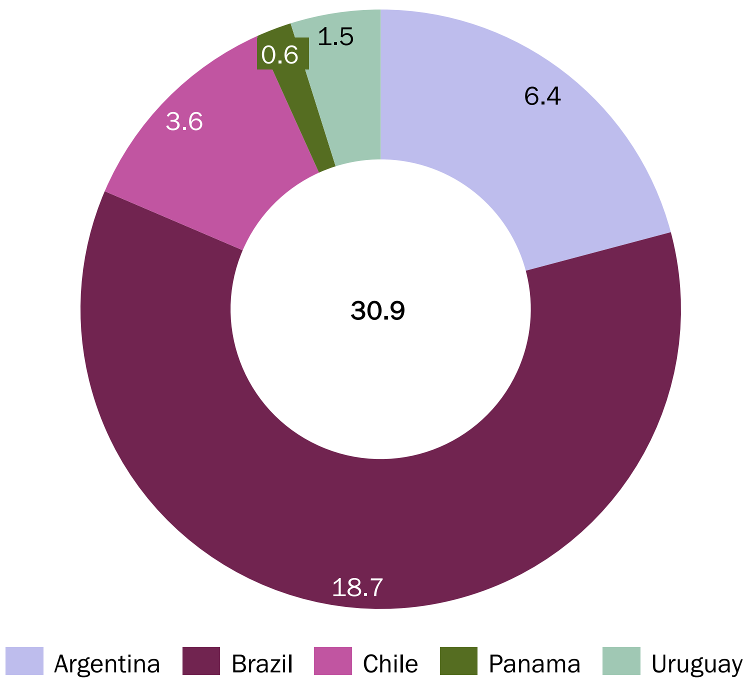


Figure 3.8: GDP impact in 2027 of Google's submarine cable deployments (real 2021 USD billion) [Source: Analysys Mason, 2022]

The economic benefits from submarine cable investments also translate into jobs. These include direct jobs in the construction and telecoms sectors, as well as indirect jobs resulting from increased broadband connectivity across the wider economy. For example, this could include jobs in industries such as IT, manufacturing, and financial services.

Based on an assessment of the gross value added (GVA) created by an average full-time worker in these industries in each of the relevant Latin America economies, we estimate that the GDP impact of Google's submarine cable investment will translate into around 740,000 jobs by 2027, as shown in Figure 3.9 and Figure 3.10.[35]

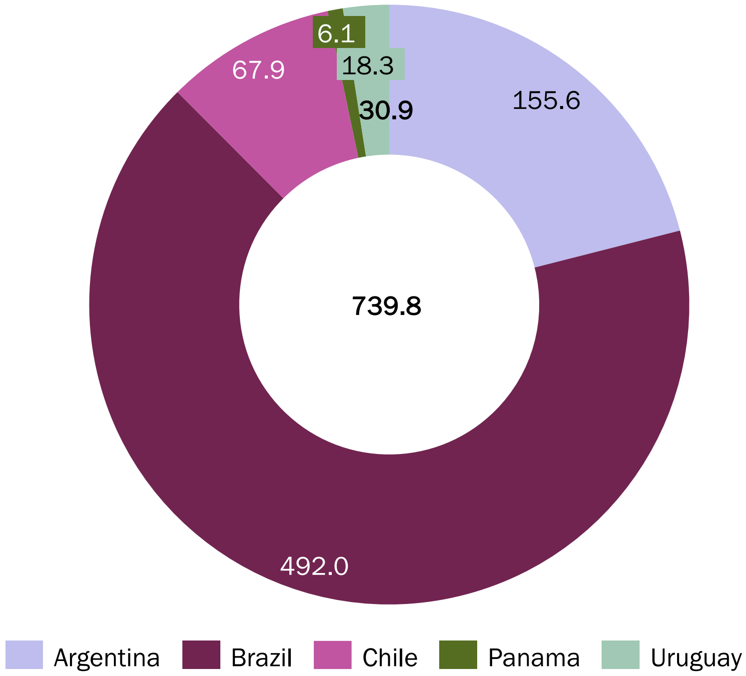


Figure 3.9: New jobs created as a result of Google's submarine cable deployments by 2027 (thousand) [Source: Analysys Mason, 2022]

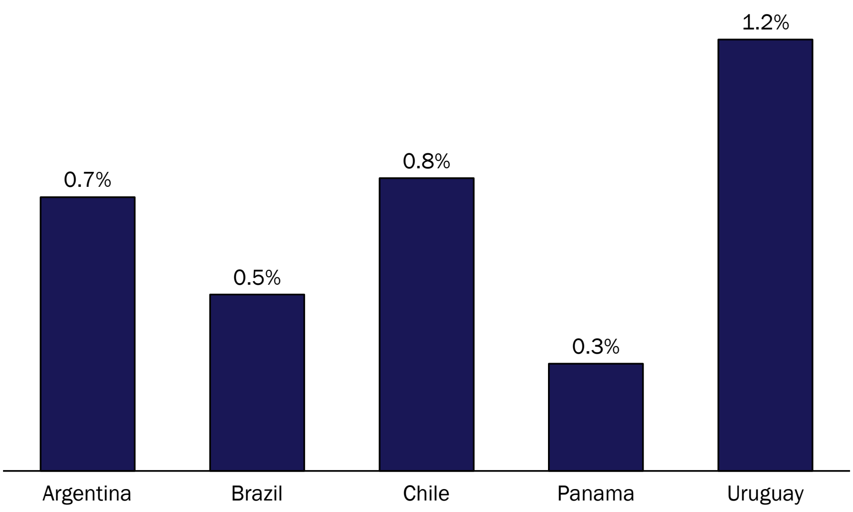


Figure 3.10: New jobs created as a result of Google's submarine cable deployments by 2027, compared to a hypothetical scenario in which no Google cables have been deployed (%increase in jobs) [Source: Analysys Mason, 2022]

35 The calculation accounts for the entire GDP impact, but apportions it to jobs based on the productivity of jobs in a few, higher value-added sectors on which digital technologies have been shown to have an impact

4 Straightforward, transparent, and supportive regulatory regimes in Latin America are important for encouraging submarine cable infrastructure investments

Due to the major investments required to launch a submarine cable, it is important that the processes involved are as efficient and streamlined as possible, with minimal regulatory uncertainty. Lower risk and less complexity from a regulatory perspective are essential in encouraging the deployment of submarine cables in a country, as this helps to generate a business-friendly environment. A series of measures would be helpful in this context, as explored in this section:

- straightforward, transparent, clearly laid out and consistent procedures for obtaining the licenses and permits needed to lay and land submarine cables
- a single agency providing a sole point of contact for license and permit applications
- implementation and enforcement of effective cable-protection laws
- a quick and straightforward application process for inspection, maintenance, and repair of submarine cables once they have been deployed, with cable works (both deployment and maintenance) exempt from cabotage restrictions
- an open investment policy welcoming foreign investment in the country, allowing foreign investors to finance the deployment of submarine cables.

4.1 A transparent, consistent licensing regime would facilitate the deployment and maintenance of cables in Latin America

The process for acquiring all the necessary permits should be clearly documented and easily accessible

In most cases, long stretches of submarine cable are deployed through international waters. However, branches leading to landing points in particular countries can require numerous permits and licenses from the country in question. The more straightforward the process is for acquiring such permits, the more business-friendly the environment, which in turn facilitates the major investment decisions required. The points covered in this subsection refer to the deployment of submarine cables, as well as to their maintenance and repair. These activities involve different challenges; for example, in the case of maintenance/repair, an agile and quick process is particularly important, to minimize any impact on quality of service.

In terms of the process for acquiring permits, the first key point is for all processes to be well documented, with all the necessary steps clearly set out and all information easily accessible. This represents an immediate issue in many countries in the Latin America region, due to the scarce levels of information that is easily available. Countries with examples of good practice in this area include:

- *Argentina* – the steps required to secure a permit from the regulator are set out clearly on Enacom's website,[36] although this is just one of various permits required
- *Colombia* – all the various pieces of documentation/licenses required are set out in a resolution on the website of Dirección General Marítima (DIMAR), the national maritime authority.[37]

The regulatory burden involved in securing permits should be limited, and require interaction with one central point of contact rather than various agencies

Beyond the documentation of the required steps, the processes themselves should preferably be straightforward, requiring interaction with a limited number of different agencies and/or government bodies, or ideally just one central point of contact. If multiple agencies are involved, their objectives should be aligned, and good communication should be maintained among them all. This is generally not yet the case in Latin America: while the steps for securing a license from the regulator in Argentina are clearly set out, this is only one of multiple pieces of documentation that are required, with others being complex to manage (for example, processes related to the importation of equipment); similarly, the process in Colombia requires interaction with numerous different government agencies/bodies.

> *"In Brazil, three agencies are involved in the submarine cable licensing process (environmental, navy and telecoms). This can be difficult as these three parts are separate, so the process for licensing can be very slow"*
>
> **International CDN**

We understand from our discussions with industry participants that many of the permitting processes with the different agencies, particularly at a local level, can be very bureaucratic, requiring a significant investment of both time and effort from the party interested in deploying a cable. In certain countries in the region, Google has experienced challenges with the administrative burden associated with importation, permitting, and licensing. Obtaining customs clearances can be very slow, and bringing in foreign vessels is not particularly straightforward. On one occasion, a vessel had to be left sitting idle for one month before it could start work on a marine survey, as the process of temporary admission and customs clearance took weeks). Furthermore, in some cases, laws and regulations are also somewhat ambiguous, which means that interpretation of the relevant legislation can depend on the understanding of an individual official. In general, in order to create the most

36 https://www.enacom.gob.ar/tramites/autorizacion-solicitud-permiso-instalacion-cables-submarinos-mar-argentino_t87

37 https://www.dimar.mil.co/sites/default/files/res06022015.pdf

welcoming environment for submarine cable investments, it is essential to have a streamlined process which minimizes bureaucracy and is clearly defined in order to avoid any ambiguity.

> *"The real barrier for securing permits can be the municipalities where the cables land. Some feel that they have a geographic advantage and want to take advantage of this"*
>
> Global tech company

We also understand that the complexities at local/regional level can extend beyond bureaucratic burdens. Even if the processes are relatively straightforward at a national level, there is no guarantee that this will be the case in local municipalities, for example. One problem that can arise is if a municipality that has been chosen as the location for a landing station believes it deserves specific benefits, beyond the general improvements to connectivity that will be enjoyed by the region as a whole. As a result, the municipality might request specific additional network deployments or services to bring direct benefits, and discussions on this can significantly delay the granting of a permit, and therefore the deployment of a cable. However, issues like this cannot arise in countries such as Brazil, where a municipality is not permitted to ask for additional services (e.g. free Internet services for its inhabitants) from a company making a telecoms infrastructure investment. Ensuring uniformity and consistency between local municipalities is another important way to facilitate a business- and investment-friendly environment.

It is important for agencies granting licenses and permits to have sufficient institutional knowledge of the processes involved

Linked to the need for clearly defined processes is the fact that submarine cable deployment can be a relatively rare event, and it is possible that long periods pass without a single cable being deployed in a region/country. As a result, in some cases only a limited number of individuals in the relevant national government and local government agencies may have the knowledge needed to manage the permit application process efficiently. Issues related to institutional knowledge/understanding are thus another possible challenge and cause of delays. It is important for each agency involved to maintain an up-to-date and thorough understanding of the processes and issues at hand. In addition, this knowledge should be shared among various individuals in order to prevent bottlenecks, and avoid the risk of loss of knowledge should one particular person leave the agency or move to a different role.

4.2 Cable-protection laws and cabotage laws need to be designed carefully to avoid causing unnecessary regulatory burden

Cable-protection laws provide added reassurance, but they need to be well designed to avoid unintended consequences

Submarine cable-protection laws provide an important added layer of reassurance for parties which are considering whether to deploy a cable, as they reduce the risk of future problems and increased maintenance/replacement needs. The aim of these laws is to provide a corridor which extends a set distance either side of a cable where certain activities that could damage it, such as fishing, are not permitted. Examples of countries with such rules include:

- *Colombia*, which has banned a range of marine activities (such as trawl fishing) within 500m on either side of a submarine cable.[38]
- *Uruguay*, which has banned all fishing activities within a nautical mile (around 1.9km) either side of submarine cables.[39]

While cable-protection laws are mainly beneficial for submarine cable operators, and should be encouraged, it is important to ensure that they do not have unintended negative consequences. Legislation which bans fishing within certain areas naturally tends to be unpopular in the fishing industry, and can lead to lobbying to limit the number of areas where such bans apply. A possible consequence of this is that the relevant government agencies may then try to limit the areas where cables are deployed, to minimize the impact on fishing.

There are several reasons why it can be problematic to establish an effective protected corridor where all submarine cables must be deployed:

- It reduces geographical diversity on cable routes, which can have an impact on redundancy, since all cables are deployed in the same area. The geographical clustering of cables increases the risk of multiple cables being damaged, leading to network outages from a single natural disaster or man-made event.
- It can force submarine cable operators to deploy routes which are not the optimal design and in locations which they would not select if they had a greater degree of freedom to choose. This lack of efficiency can deter operators from making the ultimate decision to invest in a deployment.
- It can put strain on landing-station availability. If limited space is available at the landing station(s) deployed in the protected corridor, this can be another impediment to cable deployment, either because there is simply no space for a new cable, or because the limited space allows the landing station operator to charge high prices.
- Cable corridors may be narrow and so may provide insufficient spatial separation from other submarine cables to support efficient installation and maintenance processes.

Therefore, while the effective protection of cables is important, it should not be at the expense of restricting possible routes and optimal deployment practices, geographical variation, and economic efficiency of landing-station use. Careful stakeholder consultation and engagement with all seabed users should be undertaken before any such scheme is established.

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38 https://www.dimar.mil.co/sites/default/files/normatividad/res_02042012.pdf

39 https://www.convergencialatina.com/Nota-Desarrollo/112061-3-45-Aprueban_un_nuevo_reglamento_para_proteger_cables_submarinos

Exemption from cabotage laws and certain importation laws/processes would help to ensure that maintenance and repairs can be carried out as quickly as possible

Cabotage laws are generally applied to the shipping industry as a way of preserving domestically owned shipping infrastructure and ensuring safety in territorial waters. Examples of this type of law include limits on the number of days that a foreign ship can be in territorial waters carrying out works. This is not solely an issue in Latin America, but is a global phenomenon, and these types of laws are in place across most of the countries of interest for this study.

In general, while we understand from conversations with industry participants that these laws need to be managed, and the associated processes negotiated, they do not generally represent a major inconvenience in the region. There are exceptions to this, however: one example was cited of a vessel sitting idle for a month in Brazil before it could start work on a marine survey, as the temporary admission of the vessel and customs clearance took several weeks (instead of just the couple of days it would take in most countries). In Argentina, local ship operators have the opportunity to claim that they could do the work, and should be given the opportunity ahead of a foreign ship. The additional administrative burden and time involved in these processes can extend the time needed for both maintenance/repair work (when time is of the essence, particularly if an incident is affecting the quality of service provided, or limiting connectivity) as well as initial cable deployment.

Beyond cabotage laws, maintenance/repair can also be somewhat hindered by complicated importation and customs processes in certain countries. The example of Brazil was given, where if a broken piece of equipment needs to be taken out of the country for repair work and then brought back, it may be necessary to declare which component has been repaired when bringing it back into the country, in order to avoid paying full duties on the piece of equipment for a second time. This level of scrutiny and detail is a further example of a process that can add time to maintenance/repair works.

4.3 Foreign ownership and investment appear to be generally welcomed in Latin America, which is a state of affairs that should be encouraged

Another important feature of a positive environment for submarine cable investment is that foreign investment in cable ownership is welcomed. From our discussions with industry participants, we understand that this is generally the case in the countries of interest in Latin America. At a national level, authorities are generally seen to be open to foreign parties investing in telecoms infrastructure, particularly in markets with "developing" infrastructure. This provides a contrast to other regions, such as Asia–Pacific, where there is not necessarily such an inviting vision in all countries.

Despite the fact that foreign investment in LAC is generally welcomed and viewed in a positive light, there can still be complications for foreign infrastructure investors in certain countries in the region. An example of this is Brazil, where it can be necessary to set up separate entities within the country, as well as dedicated bank accounts. While this clearly does not mean that investors will not deploy submarine infrastructure in the country, it represents another bureaucratic hurdle that needs to be negotiated as part of the planning/deployment process.

Annex A Economic impact assessment methodology

This annex details the quantitative, econometric approach that Analysys Mason used to estimate the GDP and job impact resulting from Google's submarine cables in LAC. This work was conducted by Professor Neil Gandal (see biographical details below) with support from Dr Michael Kende (Senior Adviser to Analysys Mason, Senior Fellow, and Visiting Lecturer at the Graduate Institute in Geneva, Digital Development Specialist at World Bank/IFC).

Professor Neil Gandal is the "Henry Kaufman Professor in International Capital Markets" at the Berglas School of Economics at Tel Aviv University. He received his BA and BS degrees from Miami University (Ohio) in 1979, his MS degree from the University of Wisconsin in 1981, and his PhD from the University of California-Berkeley in 1989. He is also a research fellow at the Centre for Economic Policy Research (CEPR).

Professor Gandal has published numerous empirical papers using econometrics in industrial organization, the economics of information technology, the economics of the software and Internet industries, and the economics of cyber security and cryptocurrencies. His papers have received more than 7000 citations at Google Scholar.

In his capacity as managing editor at the International Journal of Industrial Organization (IJIO) from 2005 to 2012, he edited many empirical papers using a wide range of econometric techniques. Following his editorship at the IJIO, he was named "Honorary Editor" of the journal. He is the only honorary editor in the history of the IJIO.

A.1 Background and objectives

Our methodology uses a model that enables us to assess the impact of individual submarine cables in individual countries. This model rests on a set of equations, derived from statistical analysis of data on submarine cables, Internet connectivity statistics, and economic output, across the entire LAC region.

Formally, these equations are based on statistical regressions that analyze the association between the number of submarine cables and connectivity 'supply', then between connectivity supply and demand.

A second module, based on a different type of econometric model, called an 'endogenous growth model', isolates the impact of demand for connectivity on economic growth.

Ultimately, this model enables us to simulate the connectivity environment, and its impact on economic growth, in two main scenarios:

- **A scenario that includes Google's investments in submarine cables**, including Google-invested cables already present in the region (Tannat, Curie, Monet, and Junior)[40] as well as Firmina, which is scheduled to be ready for service in 2023; this scenario also reflects the presence of all other submarine cables in the region, and takes into account planned and announced cables by parties other than Google.
- **A scenario that excludes Google-invested cables**, which simulates a situation where these cables would not be present; in this scenario, all other submarine cables are left unchanged, as per the first scenario.

By simulating the difference between these two scenarios, we arrive at an estimate for the total impact of Google's submarine cable investments in LAC. Removing a Google cable leads to worse connectivity supply variables, which in turns leads to lower demand for connectivity. This lower demand for connectivity translates into lower economic growth, and a GDP output that is lower than in the scenario where the cable is present. The difference in GDP calculated in both scenarios represents the economic impact of Google-invested cables. There is no job creation benefit in this negative scenario (for details of job creation see Section A.4.2).

A.1.1 Statistical model: variables and approach

Before we delve into each part of the estimation process, we first provide a brief background on why we modelled the process in the way we did and then briefly discuss the data employed in the analysis.

Consumer demand for connectivity is the product of several factors. Intuitively, we made the hypothesis that this demand is driven by low prices and high-quality connectivity. This is borne out by interviews with technical expects and market participants, and illustrated in a few quotes:

"*While bandwidth plays a big role in how fast webpages load, the journey from one machine to another takes time to traverse. No matter how much data you can send and receive at once, it can only travel as fast as latency allows*."[41]

"*True Internet speeds comes down to a combination of bandwidth and latency.*"[42]

Quality itself depends on a range of factors, but from a technical perspective it is a product of high bandwidth, low latency, and high reliability. Through our analysis in previous studies,[43] we

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40 Junior is a domestic system within Brazil, but in the analysis we treat it as an extension of international cable systems linking Brazil to other countries

41 Cody Arsenault, *Understanding Network Bandwidth vs Latency*, see: keycdn.com/blog/network-bandwidth

42 *Plug Things In – What is Latency – How is Latency Different from Bandwidth*, see: http://www.plugthingsin.com/Internet/speed/latency

43 *Economic impact of Google's APAC network infrastructure*, see: https://www.analysysmason.com/consulting-redirect/reports/impact-of-google-network-apac-2020

established that bandwidth, latency, and prices could have a statistically significant impact on Internet penetration and the intensity of use of the Internet.

In addition, since demand also depends on retail prices to consumers and businesses, on the supply side, we estimate how investments in submarine cables affect IP transit prices. Despite the growing importance of direct peering relationships between ISPs and content and application providers (CAPs), IP transit remains an important component of retail Internet service, for which some price information is available, and where prices respond rapidly to the prevailing international connectivity environment. As a result, the price of IP transit is expected to have an impact on retail prices to consumers and business. That is, a fall in IP transit prices typically leads to a fall in retail prices.

We therefore set out to build a model that tests the relationship between the number of submarine cables landing in each country in each year with the supply-side variables (price, bandwidth, and latency), as shown in Figure A.1.

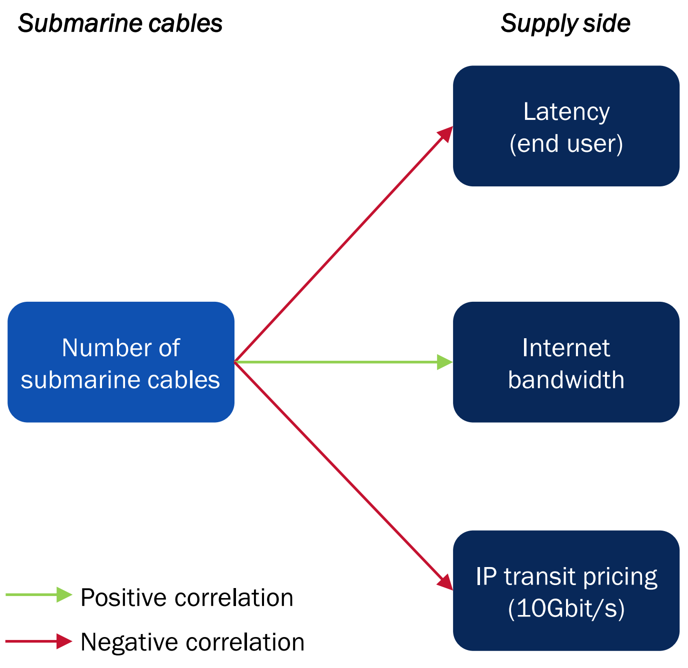


Figure A.1: Impact of the number of submarine cables on price and quality of connectivity [Source: Analysys Mason, 2022]

Economic and social impact of Meta's submarine cable investments in APAC, see: https://www.analysysmason.com/consulting-redirect/reports/meta-submarine-cable-investments-asia

A Single Digital Market for East Africa, see: https://www.analysysmason.com/consulting-redirect/reports/sdm-for-east-africa-may2019

The analysis then assesses the impact of 'supply variables' on connectivity demand, in the form of data usage and Internet penetration, as shown in Figure A.2.

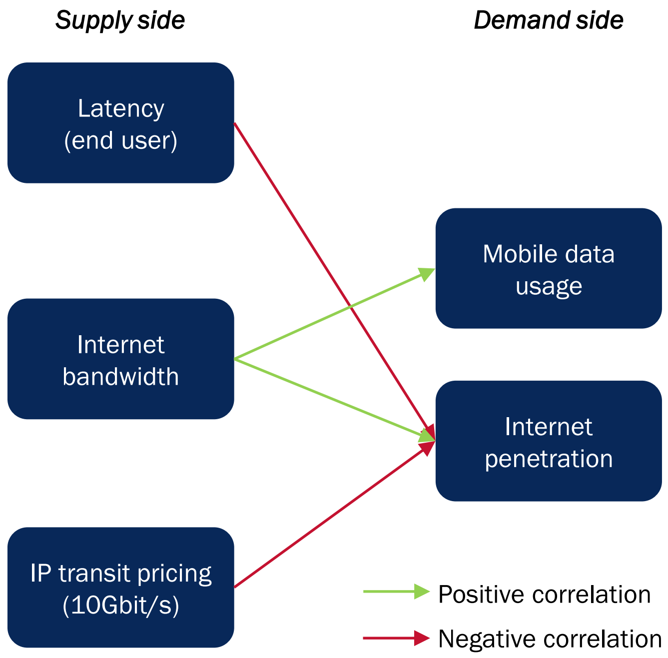


Figure A.2: Impact of price and quality of connectivity (bandwidth and latency) on Internet penetration and mobile data usage [Source: Analysys Mason, 2022]

In the context of this study, we define these variables as follows:

- *Price* is represented by IP transit prices[44]
- *Bandwidth* is represented by the International Telecommunication Union's (ITU's) measure of the availability of Internet bandwidth
- *Latency* is measured as the average latency in mLab's data, where the test is conducted from a country in the region[45]
- *Internet penetration* is measured by the ITU as number of Internet users per 100 inhabitants
- *Data usage* reflects reported mobile data usage per user, and the resulting overall traffic, based on publicly available data and additional input we were able to obtain from individual regulators[46]
- *GDP* data (introduced in Figure A.3) is provided by the World Bank, and we use additional data on GVA per job for different sectors to estimate the job impact of higher GDP.

The economic impact reflects the broader effects of better connectivity on productivity and output. More submarine cables lead to better connectivity supply, in the form of higher quality and lower prices. This drives demand for Internet connectivity, which stimulates broader economic growth.

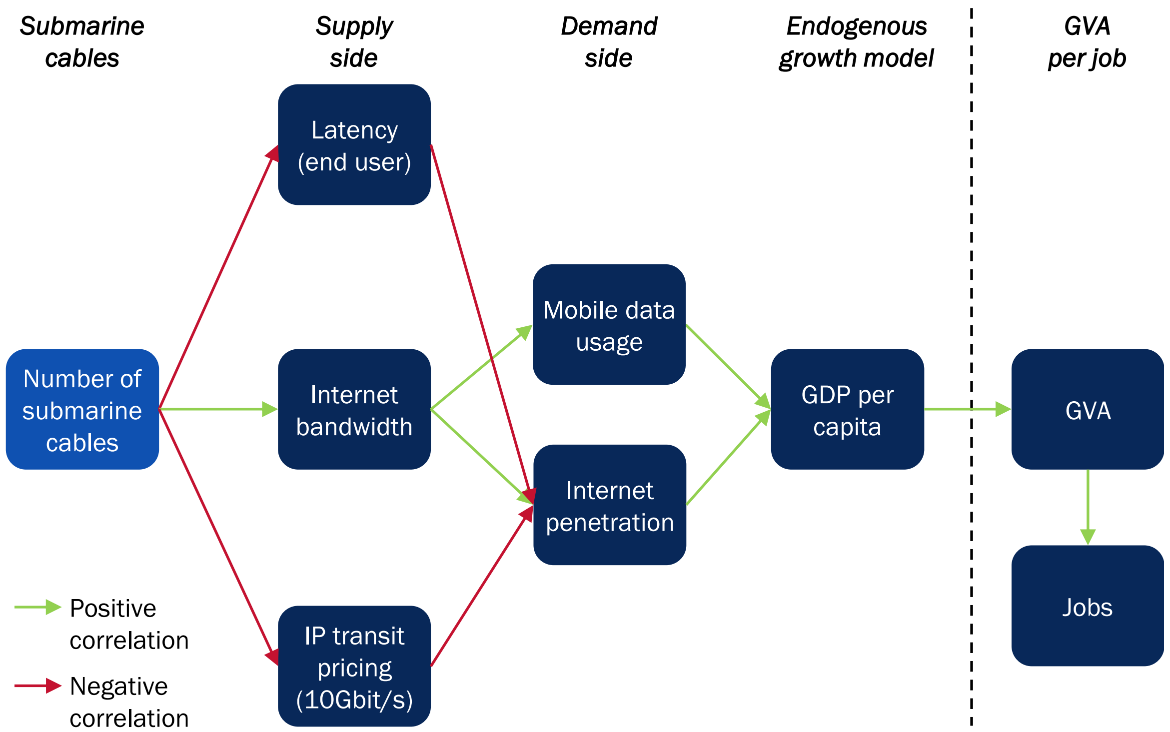
44 For 1Gbit/s and 10Gbit/s committed capacity, measured on a per-month, per-Mbit/s basis

45 This includes tests that are domestic and remote, which reflect both international connectivity and the presence of in-country content, both of which affect quality and demand; see https://www.measurementlab.net/data

46 We do not have enough data observations to estimate fixed data traffic. This is not a problem, however, because (i) mobile data traffic is increasing much faster than fixed data traffic and (ii) there is a high positive correlation between these variables

Our modeling therefore captures the direct and indirect economic impact of submarine cables, including spillover effects in the rest of the economy that can be observed in historical data.

Figure A.3: Overall flow for modeling the submarine-cable impact [Source: Analysys Mason, 2022]



A.1.2 Data used in the analysis and calibration of the statistical models

The data for this analysis consists of panel data from countries in the LAC region over the 2010–2020 period. Panel data involves repeated observations over time for the countries in the analysis. For some countries, we do not have complete observations on all of the variables. Hence, we have what is referred to as an "unbalanced panel". Fortunately, we have a fairly large dataset, which enables relatively precise estimates of the key effects.

Having a panel rather than cross-sectional data is advantageous, since a cross-section cannot control for time-invariant 'country' effects; they are included in the error term in cross-sectional analysis.[47] If these unobserved effects are correlated with the right-hand-side variables, the estimates from the cross-sectional analysis will be biased; however, we eliminate this problem by using "fixed-effect models".

47 Cross-sectional data is the result of a data collection, carried out at a single point in time on a statistical unit, see: https://www.statista.com/statistics-glossary/definition/357/coss_sectional_data

A.1.3 Estimation and fixed effects models

Our estimation covers three parts of the model.

- In Section A.2, we estimate the supply-side impacts that an increase in submarine cable supply from investments in submarine cables has on (I) latency, (II) Internet bandwidth per user, and (III) IP transit prices.
- In Section A.3, we then estimate the demand-side impact that latency, Internet bandwidth, and IP transit prices have on (IV) mobile data traffic and (V) the penetration rate.
- In Section A.4, we estimate equation (VI and VII) which measures the GDP-per-capita impact from (VI) an increase in mobile data traffic and (VII) the penetration rate using an endogenous growth model.

We illustrate the importance of using a fixed-effect model by using as an example the demand model we employ for Internet data traffic:

$$(*) \qquad \mathbf{R_{it} = \alpha_i + X_{it}\omega + \varepsilon_{it}.}$$

The variable R_{it} is annual Internet data traffic in country *i* in year *t* – i.e., the total mobile Internet usage of an entire country's population per capita in a given year.

The vector $\alpha_i \equiv \alpha + A_i'\delta$ is such that α is a constant and A_i is a vector of unobserved time-invariant country factors. Given these unobserved time-invariant project factors, equation (*) should be estimated using a fixed-effect model in which $\alpha_i \equiv \alpha + A_i'\delta$ are parameters to be estimated.[48] The δ parameters are typically not of interest, but rather are controls.

The variables in X_{it} are observable time-varying country factors (like bandwidth per capita and latency) and ω are parameters to be estimated. These parameters indicate the impact of the factors on Internet data traffic. Hence, the ω parameters are the ones we are the interested in. Finally, ε_{it} is an error term.

We employ these fixed-effect models for equations I to V. In Section A.4, we discuss the endogenous growth equations employed in equation (VI and VII).

48 As Angrist and Pischke note, treating α_i as parameters to be estimated is equivalent to estimating in deviations from the mean; see Angrist, J. and Pischke, J., 2009, 'Mostly Harmless Econometrics', Princeton University Press, Princeton, New Jersey

A.2 Supply-side estimation: how submarine cable supply affects (I) latency, (II) Internet bandwidth, and (III) IP transit prices

The goal in this section is to examine how submarine cable supply affect latency, Internet bandwidth, and IP transit prices.

We have three supply equations:

(I) latency
(II) Internet bandwidth
(III) IP transit prices.

The results of the analysis are coefficients that enable us to calculate latency, bandwidth, and IP transit prices as a function of the number of submarine cables, as shown in Figure A.4 below. These are explained further in the following subsections.

Figure A.4: Fixed effects supply-side regressions – explaining latency, Internet bandwidth, and IP transit prices[49] [Source: Analysys Mason, 2022]

	Regression I: latency (log/log) Estimates (std. error)	Regression II: Internet bandwidth per user (log/log) Estimates (std. error)	Regression III: IP transit prices (log/log) Estimates (std. error)
Submarine cables	-0.20*** (0.02)	1.30*** (0.11)	-0.80*** (0.069)
Observations	360	394	172

Note: * p < 0.10, ** p < 0.05, *** p < 0.01

A.2.1 Supply side: latency

We begin with equation (I) latency. We use a log/log functional form which is typically employed in empirical work.[50]

$$\textbf{(I)} \qquad L_{it} = \alpha_i + \beta^* C_{it} + \varepsilon_{it}.$$

Where:

- L_{it} is the natural logarithm of latency in milliseconds for round-trip time as of December of each year.

[49] All variables are in natural logarithms

[50] The coefficients (α β, δ, etc.) in all of our equations are, of course, different. We use the same notation for simplification and clarity

- C_{it} represents the natural logarithm of the number of submarine cables (plus one). The way we do this is, for each new cable we assume that it takes four years to be fully operational and efficient from when it is ready for service. Hence, in year one, it is 0.25, in year two 0.50, etc.

As mentioned earlier, the "it" subscript means "in country *i*, in year *t*".

The results of estimating equation (I) are shown in the first regression in Figure A.4. The negative coefficient on the number of open submarine cables makes sense. Latency (time) falls when the number of submarine cables increases. The estimated coefficient in Regression I in Figure A.4 is statistically significant at the 99% level of confidence.

Since the variables are in natural logarithms, the coefficient is an elasticity and can easily be interpreted. For example, a coefficient of -0.20 means that a 1% increase in the number of open submarine cables reduces latency by -0.20%.

A.2.2 Supply side: Internet bandwidth

We now estimate equation (II), the Internet bandwidth per user equation.

$$\textbf{(II)} \qquad \mathbf{IBW\_per_{it} = \alpha_i + \beta * C_{it} + \varepsilon_{it}.}$$

Where:

- IBW_per_{it} is the natural logarithm of the total used capacity of international Internet bandwidth per user (measured as the sum of capacity of all Internet exchanges offering international bandwidth divided by the number of users).
- C_{it} is the same explanatory variable we used in equation (I).

The results of estimating equation (II) are shown in the second regression in Figure A.4. The positive coefficient on the number of submarine cables makes sense, as Internet bandwidth per user increases when the number of open submarine cables increases.

Since the variables are in natural logarithms, the coefficient is an elasticity and can easily be interpreted. For example, a coefficient of 1.30 means that a 1% increase in the number of open submarine cables increases Internet bandwidth per user by 1.30%. The estimated coefficient is statistically significant at the 99% level of confidence.

A.2.3 Supply side: IP transit price

We now estimate equation (III), the IP transit price equation.

$$\textbf{(III)} \qquad IP_{it} = \alpha_i + \beta{*}C_{it} + \varepsilon_{it}.$$

Where:

- IP_{it} is the natural logarithm of the IP transit price. This is the price for a committed data rate of 1Gbit/s, averaged over all four quarters of each year, normalized per Mbit/s per month.[51]
- C_{it} is same explanatory variable we used in equation (I).

The results from equation (III) are shown in the third regression in Figure A.4. The negative coefficient on the number of open submarine cables makes sense, as IP transit prices fall when the number of open submarine cables increases.

Again, since the variables are in natural logarithms, the coefficient is an elasticity and can easily be interpreted. The results show that a 1% increase in the number of submarine cables reduces IP transit prices by 0.80%. As the table shows, the estimated coefficient is statistically significant at the 99% level of confidence.

A.3 Demand-side estimation: how (I) latency, (II) Internet bandwidth, and (III) IP transit prices affect (IV) mobile data usage

In this section we estimate the demand-side equation for mobile data traffic that depends on the three variables modelled with the supply-side equations: latency, Internet bandwidth, and IP transit prices.

Figure A.5: Demand-side regressions – explaining (IV) mobile Internet data traffic and Internet penetration [Source: Analysys Mason, 2022]

	Regression IV: Mobile Internet data usage Estimates (std. error)	Regression V: Mobile Internet data traffic Estimates (std. error)
Internet bandwidth per user	1.85*** (0.28)	0.11*** (0.27)
Latency	0.37 (0.72)	-0.20** (0.088)
IP transit price	-0.28 (0.26)	0.10*** (0.035)
Observations	45	102

Note: * p < 0.10, ** p < 0.05, *** p < 0.01

51 We found very similar results when looking at the price of IP transit connections at 10Gbit/s committed data rate, so both can be used interchangeably

A.3.1 Demand side: mobile data traffic

We now estimate equation (IV), the demand-side equation for mobile data traffic.

$$\textbf{(IV)} \qquad D_{it} = \alpha_i + \beta * IBW\_per_{it} + \gamma L_{it} + \delta IP_{it} + \varepsilon_{it}.$$

All variables are in natural logarithms.

Where:

- D_{it} is the total cellular data usage (downstream and upstream) generated by all devices (including fixed-wireless devices) in a given period per capita. It includes both business and residential segments for country *i* at time *t*. We call this variable mobile (Internet) data usage.
- IBW_per_{it} is Internet bandwidth per capita, as defined above.
- L_{it} is latency, as defined above.
- IP_{it} is the price of IP transit, as defined above.

We make the following assumptions in order to estimate equations (IV) and (V) below:

1. There is monopolistic competition in the provision of IP transit data. This means that the price (IP_{it}) in country *i* at time *t* is a multiple (greater than one) of the marginal cost (MC) of the provision of IP transit data in country *i* at time *t*. While international services may have more market power in some countries, policy and regulatory pressures may take the place of competition in restraining the price.

2. The marginal cost (MC) of the provision of Internet service to business or residential segments is a constant (τ) multiplied by the price of IP transit data: $MC_{it} = \tau IP_{it}$.

3. We assume that there is also monopolistic competition in the provision of Internet service. Thus, the price is a multiple of the marginal cost, where the multiple (ξ) is greater than one.

Taken together, these three assumptions mean that the price of the provision of Internet service PIS_{it} is a multiple of the price of IP transit.

In other words, thus, $PIS_{it} = \xi * \tau * IP_{it}$ where the price of IP transit data is itself a function of its marginal cost.

We assume that the marginal costs are determined by technology; that is, marginal cost is exogenous to the equations we are estimating. This means that the retail price of the provision of Internet service is exogenous. This is important, because it means that we do not have simultaneous equations bias. Such bias occurs when the price is endogenous.

Now, of course we do not know ξ or τ. But since equation (IV) is in logarithms, note that $\ln(PIS_{it}) = \ln[\xi * \tau * IP_{it})] = \ln(\xi) + \ln(\tau) + \ln(IP_{it})$. Since $\ln(\xi)$ and $\ln(\tau)$ are constant, they become part of the coefficient of the constant and are not necessary for our estimation. Hence, we can estimate equation (IV) above without knowing ξ or τ.

The results of the estimation of equation (IV) are shown in Figure A.5. Mobile Internet data traffic increases when Internet bandwidth increases. While latency and price likely have an impact, it cannot be isolated. This is likely due to the small number of observations (N=45) we have available for the regression.

Since all of the variables are in natural logarithms, the coefficients are elasticities and can easily be interpreted. The estimated coefficient on Internet bandwidth means that a 1% increase in Internet bandwidth per user leads to a 1.85% increase in mobile Internet data traffic. This estimated coefficient is significant at the 99% level of confidence.

A.3.2 Demand side: Internet penetration

We now estimate equation (V), the demand-side equation for Internet penetration.

$$\textbf{(V)} \qquad \mathbf{R_{it} = \alpha i + \beta * IBW\_per\_{_{it}} + \gamma L_{it} + \delta P_{it} + \varepsilon_{it}.}$$

Where:

- R_{it} is the penetration rate; the percentage of Internet users in the population who are Internet users in country i at time t.
- $IBW\_per\_{_{it}}$ is the Internet bandwidth per user, as defined above.
- Lit is latency, as defined above.
- PI_{it} is the price of IP transit, as defined above.

The coefficients on the explanatory variables make sense: the penetration rate increases when Internet bandwidth per user increases; the penetration rate increases when latency decreases; and the penetration rate increases when the price declines. All of these effects are statistically significant.

The coefficients on Internet bandwidth per capita and IP transit price are significant at the 99% level of confidence. The estimated coefficient on latency is significant at the 95% level of confidence.

Since all of the variables are in natural logarithms, the coefficients are elasticities and can easily be interpreted.

The estimated 0.12 coefficient on Internet bandwidth per user means that a 1% increase in Internet bandwidth leads to a 0.12% increase in the penetration rate.

Similarly, the estimated -0.20 coefficient on latency means that a 1% decrease in latency leads to a 0.20% increase in the penetration rate.

Finally, the estimated -0.10 coefficient on price means that a 1% decrease in price leads to a 0.10% increase in the penetration rate.

A.4 Endogenous growth model for estimating economic impact: GDP and job creation

A.4.1 Impact on GDP from change in mobile data traffic

Endogenous growth models became popular in the 1980s. Such models are different from traditional (classical) growth models, because endogenous growth models assume that growth is an endogenous outcome, not the result of (say) external technological progress. Paul Romer provides a survey in the *Journal of Economic Perspectives*.[52]

In the telecoms literature, endogenous growth models have been used to examine the relationship between changes in telecoms use and economic growth.

The model we employ comes from an IMF paper by Andrianaivo and Kpodar (1994).[53] In that paper, they examined how information and communications technology (ICT) and financial inclusion affect economic growth in African countries. A modified version of the model used by Andrianaivo and Kpodar (2011) was also employed in a Deloitte/GSMA study (2012)[54] in order to estimate the impact of mobile telephony on economic growth. Hence it seems natural to employ this model.

The model can be written

$$\textbf{(VI, VII)}\ Y_{it} = \alpha_i + \rho * Y_{i,t-1} + \beta T_{it} + \gamma X_{it} + \varepsilon_{it}.$$

Where:

- Y_{it} is the GDP per capita in country *i* at time *t*.
- $Y_{i,t-1}$ is the GDP per capita in country *i* at time *t-1*.
- T_{it} is the “Internet/telecoms” variable.
- In the case of (VI), the “Internet/telecoms” variable is mobile Internet data traffic.
- In the case of (VII), the “Internet/telecoms” variable is the Internet penetration rate.

The macroeconomic variables we employ in X_{it} are:

- Ratio_govt_gdp = the ratio of government expenses to GDP in country *i* at time *t*
- Ratio_trade_gdp = the ratio of international trade to GDP in country *i* at time *t*.
- The unemployment rate = the number of people looking for work, divided by the sum of the number of people employed and the number of people looking for work.

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52 Paul Romer, 'The Origins of Endogenous Growth', 1994; see *Journal of Economic Perspectives*, Volume 8, Number 1, Winter 1994, pages 3–22

53 Andrianaivo and Kpodar, 'ICT, Financial Inclusion, and Growth: Evidence from African Countries', 2011; 'International Monetary Fund Working Paper', see: https://www.imf.org/external/pubs/ft/wp/2011/wp1173.pdf

54 Deloitte/GSMA, 'What is the Impact of Mobile Telephony on Economic Growth', 2012; see https://www.gsma.com/publicpolicy/wp-content/uploads/2012/11/gsma-deloitte-impact-mobile-telephony-economic-growth.pdf

These economic variables control for other factors that have an impact on GDP in a country.

These variables were also used in the Deloitte/GSMA (2012) study, which used a six-year horizon for estimating the endogenous growth model.

Since all of the variables are in natural logarithms, the coefficients can be interpreted as elasticities.

This is a dynamic panel data (DPD) model, since the lagged value of GDP ($Y_{i,t-1}$) appears on the right-hand side. The empirical model we employ is due to Arellano and Bond (Rev. Ec. Stud., 1991)[55] and Holtz-Eakin, Newey, and Rosen (Econometrica, 1988).[56] It uses a Generalized Method of Moments (GMM) approach. It addresses the endogeneity problem of $Y_{i,t-1}$.

By construction, the residuals of the differenced equation ($Y_{it} – Y_{i,t-1}$) should be auto-correlated of order one, i.e. an AR(1) process of serial correlation. But if the maintained assumption of serial independence in the original errors (ε_{it}) is true, the differenced residuals should not exhibit significant AR(2) behavior. If a significant AR(2) statistic is found, the second lags of the endogenous variable will not be appropriate instruments for their current values and we cannot use the model. This leads to a test, called the Arellano-Bond test, which we describe below.[57]

The results for equation (VI) are shown in the first column of Figure A.6 below. The estimate of our coefficient of interest is the one on mobile data traffic. The estimated coefficient (0.0075) is significant at the 99% level of confidence. The interpretation is that a 1% increase in mobile data use leads to a 0.0075% increase in GDP per capita.

The results for equation (VII) are shown in the second column of Figure A.6. The estimate of our coefficient of interest is the one on the penetration rate. The estimated coefficient (0.016) is significant at the 95% level of confidence. The interpretation is that a 1% increase in the penetration rate leads to a 0.016% increase in GDP per capita.

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55 Arellano and Bond, 'Some Tests of Specification for Panel Data: Monte Carlo Evidence and an Application to Employment Equations', *The Review of Economic Studies*, April 1991, Vol. 58, No. 2, pages 277–297

56 Holtz-Eakin, Newey and Rosen, 'Estimating Vector Autoregressions with Panel Data', *Econometrica*, Vol. 56, Issue 6, pages 1371–95

57 We employ the estimation procedure in Stata denoted "xtabond" to estimate the model and conduct the Arellano-Bond test, see: https://blog.stata.com/2015/11/12/xtabond-cheat-sheet

Figure A.6: Endogenous growth model – (VI) and (VII) coefficients for growth in GDP per capita [Source: Analysys Mason, 2022]

	Regression VI: GDP growth per capita (using mobile data) Estimates (std. error)	Regression VII: GDP growth per capita (using penetration rate) Estimates (std. error)
GDP per capita (lagged)	0.61*** (0.08)	0.79*** (0.054)
Mobile data usage	0.0075*** (0.0015)	
Penetration rate		0.016** (0.080)
Ratio_govt_gdp	0.034** (0.016)	-0.036 (0.023)
Ratio_trade_gdp	0.011 (0.020)	0.048** (0.020)
Employment rate	0.12 (0.12)	0.21*** (0.064)
Observations	48	330

Note: * p < 0.10, ** p < 0.05, *** p < 0.01

For equation (VI), the Arellano-Bond test for zero autocorrelation in first-differenced errors.

Order	Z	Probability > Z
1	-1.83	0.067
2	0.80	0.43

Figure A.7: Equation (VI) – Arellano-Bond test for zero autocorrelation in first-differenced errors [Source: Analysys Mason, 2022]

Since we cannot reject the null hypothesis that there is second-order autocorrelation, the assumptions of the model hold.

For equation (VII), the Arellano-Bond test for zero autocorrelation in first-differenced errors.

Order	Z	Probability > Z
1	-2.80	0.005
2	-0.33	0.73

Figure A.8: Equation (VII) – Arellano-Bond test for zero autocorrelation in first-differenced errors [Source: Analysys Mason, 2022]

Since we cannot reject the null hypothesis that there is second-order autocorrelation, the assumptions of the model hold.

A.4.2 Impact on jobs supported by the increase in GDP

Our approach to estimating the impact of Google's submarine cable investments on jobs involves three key steps, as discussed below:

- Part A: We translate the GDP impact into the GVA impact
- Part B: We estimate the average GVA per job affected by Google's investments in network infrastructure
- Part C: We estimate the job impact by dividing the GVA impact by GVA-per-job assumptions.

A.4.3 Part A: Estimation of GVA impact

We first estimate the GVA effect of the GDP impact calculated above for each country/territory, using a GDP-to-GVA ratio.[58] This allows us to relate economic impact at national level to an industry-level metric which is more directly related to factors of production, including labor and therefore jobs. For forecast years, we use the 2020 GDP-to-GVA ratio.

A.4.4 Part B: Estimation of GVA per job

Next, we estimate the GVA per job, weighted towards industries likely to be most affected by developments in broadband connectivity, for each country/territory in each year. Equinix's Global Interconnection Index[59] suggests that the primary beneficiaries of an increased consumption of Internet data traffic are likely to be the 'manufacturing', 'transport, storage and communications', and 'financial intermediation' industries.[60]

A.4.5 Part C: Estimation of job impact

Lastly, we divide the GVA impact by the calculated GVA per job for each country to estimate the number of new jobs that have been created with the higher GVA. The GVA-per-job estimates at a country level account for general growth in productivity, in line with overall economic growth. These country-level job impact estimates are then aggregated to form the overall job impact of Google's submarine cable investments. We recognize that improving digital connectivity could result in a further increase in workforce productivity and therefore an additional increase in GVA per job. Without estimating the further increase in GVA per job caused by this productivity boost, we arrive at an upper bound of the number of jobs supported by the additional GDP enabled by Google's submarine cable investments.

58 GVA is a measure of the contribution to GDP made by an individual industry; and the GDP-to-GVA ratio is derived from Euromonitor's database

59 Equinix, *Global Interconnection Index*, see: https://www.equinix.com/gxi-report

60 Based on the list of industries available as part of Euromonitor's GVA dataset

Annex B Methodology Q&A

This annex summarizes the methodology described in Annex A in a Q&A format, to address a series of questions required to understand the methodology, calculations, and results.

What impact do submarine cables have on the economy?

Submarine cables play an essential role in connecting countries with one another. Transatlantic routes have been developed since the days of the telegraph in the mid-1800s, and upgraded many times since to carry very large volumes of data. More recently, submarine cables have been deployed across the Pacific, and around continents including LAC.

With rapid growth in the amount of data consumed on the Internet and the growing importance of public cloud services, large Internet companies including Google have become major investors in submarine cable infrastructure. In Latin America, Google has invested directly in four cable systems (Curie, Tannat, Monet, and Junior), and its new Firmina system should be ready for service in 2023.

New submarine cables bring large benefits to Internet connectivity in countries where they land. They increase the bandwidth available to carry data between countries, improve the speed and latency of connectivity, and help to reduce prices. All of these factors contribute to higher-quality, cheaper Internet access for consumers, companies, and public-sector organizations. There is an established body of literature which shows that better Internet connectivity and higher demand for connectivity accelerates economic growth.

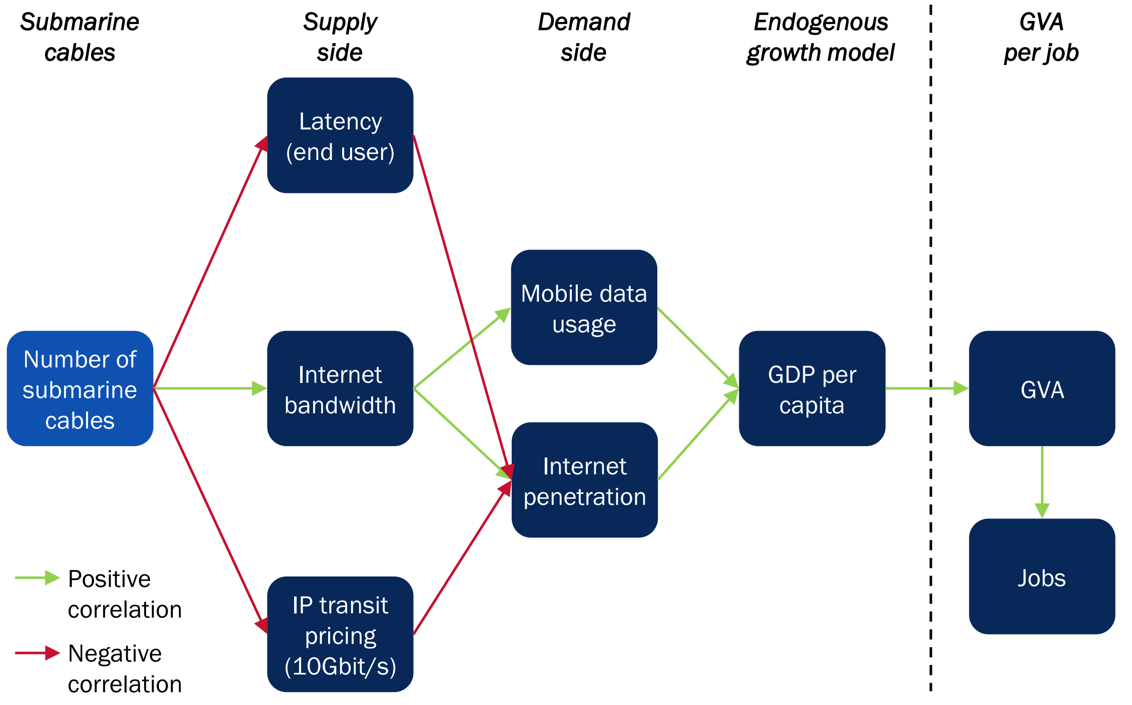
What model did you develop to measure this impact?

We built a model that analyses connectivity data for the whole LAC region, over the last decade, to understand the links between submarine cables and measures of connectivity, and the links between connectivity and economic growth specifically in the region.

We found that there was a strong, statistically significant relationship between the number of submarine cables on the one hand, and indicators of quality and price of connectivity on the other. These findings are consistent with the literature, which shows that higher demand for connectivity results in higher economic growth.

This is shown in Figure B.1 below.

Figure B.1: Overall flow for modeling the submarine-cable impact [Source: Analysys Mason, 2022]



What are latency, bandwidth, and IP transit prices and how are reductions/increases in them calculated?

These are three parameters linked to the supply of connectivity services. A lower *latency* means that the data is transported 'faster' than with a higher latency, resulting in a better perceived quality of experience and lower congestion.

Bandwidth is a key measure of capacity and speed: higher bandwidth means that a given amount of data can be transmitted faster, or that more data can be transmitted over a set amount of time.

Finally, *IP transit* is an important input for Internet connectivity, allowing ISPs and content providers to connect with one another around the world. IP transit prices are a good indicator of how expensive it is for an ISP to provide access to content across the Internet to its end users.

We estimated the impact of submarine cables on these connectivity 'supply' parameters through a statistical analysis of data available over the last decade in LAC, and applied this specifically to Google's cables to understand their impact.

How does the model estimate GDP impact?

The impact of Internet penetration on GDP has been studied by numerous entities (e.g., the ITU and the World Bank) and there is a lot of literature around this topic. In the telecoms literature, endogenous growth models have been used to examine the relationship between changes in telecoms use and economic growth.

Analysys Mason and Professor Neil Gandal employed an endogenous growth model[61] to measure the impact of Internet penetration and mobile data usage on GDP in the LAC region.

To understand the impact that new telecoms infrastructure (new submarine cables) has on Internet penetration and mobile data usage we built a model that analyses the impact that one new cable has on the supply of telecoms services. More specifically, we calculated how a new cable affects end-user latency, Internet bandwidth per user, and IP transit prices (supply-side variables).

We then analyzed the link between these supply-side parameters and the Internet penetration and mobile data usage (demand parameters).

How is the impact of a cable translated into a number of jobs created?

The economic impact of submarine cables is primarily indirect: the more cables there are, the better the connectivity, which in turn enhances the economic output in countries where cables land. Concretely, better and cheaper Internet access increases the potential of the digital economy and the productivity of the rest of the economy, in a virtuous circle that enables faster growth. This effect is quite small, but over time it results in material benefits, which we estimated in the form of a higher level of GDP through the economic model we built.

A bigger economy is associated with higher productivity and more jobs. In order to estimate the number of new jobs this larger economy can support, we assumed that productivity remains constant within the period of the analysis. We used an estimate of GVA (an important component of GDP) per job, averaged across sectors on which digitalization has the most impact, including communications and transport, financial services, and manufacturing.

What is the level of certainty around the results?

The results are based on historical data for different telecoms indicators (e.g., Internet penetration, mobile data usage) reported by national entities. As with all forecasts, there is a level of uncertainty, but our statistical analysis is based on a panel of public data reported by national and international organizations (national regulators, national statistics agencies, the World Bank) and widely used data sources (Euromonitor, TeleGeography).

The analysis conducted by Professor Neil Gandal shows that the many of the relationships used in the model are statistically significant at the 99% confidence interval, and satisfy the necessary conditions for an excellent explanatory and predictive model.

[61] See, for example, Paul Romer, 'The Origins of Endogenous Growth', *Journal of Economic Perspectives*, Winter 1994, Volume 8, Number 1, pages 3–22

Annex C Cables deployed in countries of interest

Figure C.1: List of existing international submarine cables in countries of interest [Source: TeleGeography, operator websites, 2022]

Cable	Route	Length	RFS	Design capacity	Landing points
Americas-II	LAC–US (Atlantic)	8373km	2000	5.3Tbit/s	Brazil, Curaçao, French Guyana, Martinique, Puerto Rico, Trinidad and Tobago, US, US Virgin Islands, Venezuela
América Móvil Submarine Cable System-1 (AMX-1)	LAC–US (Atlantic)	17,800km	2014	60Tbit/s	Brazil, Colombia, Dominican Republic, Guatemala, Mexico, Puerto Rico, US
Antillas-1	Intra-LAC	650km	1997	1.2Tbit/s	Dominican Republic, Puerto Rico
ARCOS	LAC–US (Atlantic)	8600km	2001	7.8Tbit/s	Bahamas, Belize, Colombia, Costa Rica, Curaçao, Dominican Republic, Guatemala, Honduras, Mexico, Nicaragua, Panama, Puerto Rico, Turks and Caicos Islands, US, Venezuela
Bicentenario	Intra-LAC	250km	2011	3.8Tbit/s	Argentina, Uruguay
Brusa	LAC–US (Atlantic)	11,000km	2018	176Tbit/s	Brazil, Puerto Rico, US
Colombia-Florida Subsea Fiber (CFX-1)	LAC–US (Atlantic)	2400km	2008	21.2Tbit/s	Colombia, Jamaica, US
Curie	LAC–US (Pacific)	10,476km	2020	72Tbit/s	Chile, Panama, US
East-West	Intra-LAC	1750km	2011	2.5Tbit/s	British Virgin Islands, Dominican Republic, Jamaica
EllaLink	LAC–Europe[62]	6200km	2021	100Tbit/s	Brazil, Cape Verde, Portugal
Fibralink	Intra-LAC	1000km	2006	7.2Tbit/s	Dominican Republic, Haiti, Jamaica
Globenet	LAC–US (Atlantic)	23,500km	2000	50Tbit/s	Bermuda, Brazil, Colombia, US, Venezuela
Malbec	Intra-LAC	2600km	2021	108Tbit/s	Argentina, Brazil

62 EllaLink also has a landing station in Cape Verde, in Africa, before continuing to Portugal

Cable	Route	Length	RFS	Design capacity	Landing points
Maya-1	LAC–US (Atlantic)	4400km	2000	2Tbit/s	Cayman Islands, Colombia, Costa Rica, Honduras, Mexico, Panama, US
Monet	LAC–US (Atlantic)	10,556km	2017	64Tbit/s	Brazil, US
Pan-American Crossing (PAC)	LAC–US (Pacific)	10,000km	2000	6Tbit/s	Costa Rica, Mexico, Panama, US
Pacific Caribbean Cable System (PCCS)	LAC–US (Atlantic)[63]	6000km	2015	168Tbit/s	Aruba, British Virgin Islands, Colombia, Curaçao, Ecuador, Panama, Puerto Rico, US
Seabras-1	LAC–US (Atlantic)	10,800km	2017	84Tbit/s	Brazil, US
South America-1 (SAm-1)	LAC–US (Atlantic)[64]	25,000km	2001	48Tbit/s	Argentina, Brazil, Chile, Colombia, Dominican Republic, Ecuador, Guatemala, Peru, Puerto Rico, US
South American Crossing (SAC)	Intra-LAC	20,000km	2000	44Tbit/s	Argentina, Brazil, Chile, Colombia, Panama, Peru, Venezuela, US Virgin Islands
South Atlantic Cable System (SACS)	LAC–Africa	6165km	2018	40Tbit/s	Angola, Brazil
South Atlantic Inter Link (SAIL)	LAC–Africa	5800km	2020	32Tbit/s	Brazil, Cameroon
South Pacific Cable System (SPCS)/ Mistral	Intra-LAC	7300km	2021	132Tbit/s	Chile, Ecuador, Guatemala, Peru
Tannat	Intra-LAC	2000km	2018	90Tbit/s	Brazil, Uruguay Argentina (RFS in December 2020)
Unisur	Intra-LAC	265km	1995	2Tbit/s	Argentina, Uruguay

63 PCCS also has a Pacific branch between Panama and Ecuador, but connects to the US in Florida and so has been classed as Atlantic

64 SAm-1 also has a Pacific branch between Guatemala and Chile, but connects to the US in Florida and so has been classed as Atlantic