Strategies and Business Models for Improving Broadband Connectivity in Latin America and the Caribbean

Guidelines for the Planning, Investment, and Rollout of Broadband Networks

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Acronyms

2G	second generation wireless telephone technology
3G	third generation wireless telephone technology
4G	fourth generation wireless telephone technology
5G	fifth generation wireless telephone technology
ADSL	asymmetric digital subscriber line
AI	artificial intelligence
AR	augmented reality
ARCOTEL	Agency for Control and Regulation of Telecommunications
BEST	Broadband Environment for Sustainable Transformation
CAF	Development Bank of Latin America
CAPEX	capital expenditure
CDMA	code-division multiple access
CFE	Federal Electricity Commission
CMT	Telecommunications Market Commission
CNMC	National Commission for Markets and Competition
CONATEL	National Telecommunications Commission
DAE	Digital Agenda for Europe
DB	development bank
DBO	design, build, operate
DFI	direct foreign investment
DWDM	dense wavelength division multiplexing
EC	European Commission
ERDF	European Regional Development Fund
ESTWIN	Estonian Wideband Infrastructure Network
EU	European Union
FDT	Telecommunications Development Fund
FOA	Austral Optical Fiber
FON	National Optical Fiber
FTTH	fiber to the home

HHI	Herfindahl-Hirschman Index
HSPA	high-speed packet access
ICT	information and communication technologies
IDB	Inter-American Development Bank
IDBA	Inter-American Development Bank Index on Broadband Development
IEEE	Institute of Electrical and Electronics Engineers
IoE	the Internet of everything
IoT	the Internet of things
IP	Internet protocol
IRU	indefeasible rights of use
ISP	Internet service provider
IFT	Federal Telecommunications Institute of Mexico
ITU	International Telecommunications Union
IXP	Internet exchange point
KADO	Korean Agency for Digital Opportunity and Promotion
KMTSC	Korea Mobile Telecommunications Service Corp.
KT	Korea Telecom
LAC	Latin America and the Caribbean
LLU	local loop unbundling
LOT	Organic Telecommunications Law
LTE	Long-term evolution
MIC	Ministry of Information and Communication
MNO	mobile network operator
MVNO	mobile virtual network operator
OECD	Organization for Economic Co-operation and Development
PEBA	Broadband Extension Assistance Plan of Spain
PoP	points of preference
PPP	public–private partnership
R&D	research and development
RFS	radio frequency systems
ROW	right-of-way
SME	small and medium-sized enterprises

SUBTEL	Under-Secretariat of Telecommunications of Chile
TMG	Telecommunications Management Group
TVWS	television white space
UHF	ultra-high frequency
USAID	United States Agency for International Development
USF	Universal Service Fund
VDSL	very-high Speed Digital Subscriber Line
VoIP	voice over Internet protocol
WEF	World Economic Forum
Wi-Fi	wireless fidelity
WiMAX	Worldwide Interoperability for Microwave Access

Executive Summary

Strategies and Business Models for Improving Broadband Connectivity in Latin America and the Caribbean

Guidelines for the Planning, Investment, and Rollout of Broadband Networks

Executive Summary

Achieving universal and affordable digital connectivity is an essential goal for all countries in Latin America and the Caribbean (LAC). Although significant progress has been made to advance the state of connectivity in the region, there are still significant challenges ahead (both from the private and public sector perspectives). These challenges include high financial and operating risks, energy supply issues, poor coordination among regulatory and policy making bodies, lack of public sector capacity and resources, and the absence of a conducive investment and regulatory climate that promotes investment and competitive principles. This is often compounded by a lack of understanding of the relationship between closing the digital divide and economic growth. LAC countries score below the Organization for Economic Co-operation and Development's (OECD) average in terms of broadband penetration, household access to information and communication technologies (ICT), and Internet adoption.

Policy makers confront a series of choices regarding technology, market regulation, and private versus public investment to expand access to broadband. Incorrect choices on any of these can result in less access at lower quality and at higher prices. This report fills a gap for the benefit of policy makers by outlining the best practices on each of these dimensions, to attract investment in broadband and to maximize broadband access and quality. This report is part of the effort of the Inter-American Development Bank (IDB) to drive change on the development of digital infrastructure in LAC, with the aim to ultimately help the region achieve universal and affordable Internet connectivity. The objective of this report is to make a compilation and analysis of global business and financial models, best practices, innovations, and progresses around the topic of digital infrastructure, including middle and last mile connectivity. It also aims at serving as a valuable tool for policy makers, regulators, government officials, as well as private sector and community leaders in LAC as they assess alternatives for improving broadband connectivity and tailor best practices and approaches to their own country's needs.

Digital Infrastructure Value Chain

Increasing broadband access and affordability cannot be achieved without first analyzing the digital infrastructure value chain. For this reason, one of the primary focus of this report is to explore its components, including the following:

- International and cross-border networks (which connect countries together and to the Internet).
- National networks (which connect cities together as well as points of presence, or PoP).
- Middle mile networks (which bring Internet to communities for further distribution).
- Last mile networks (which bring Internet from the middle mile to businesses and homes).

International, cross-border, and national networks

International and cross-border infrastructure enables national networks of two or more countries to connect and communicate with one another either via submarine or terrestrial optical fiber cables. In the case of LAC, the vast majority of submarine cables that connect the region run through the United States, with Miami serving as the main hub. One exception of this is Chile, a country which in July 2019, started to accept bids for a feasibility study on the first optical fiber cable to run between Asia and South America.

Consortia are still one of the ways for financing and building submarine cables. In this modality, the companies involved in the consortia carry the totality of capital expenditure (CAPEX) associated with the project. Other types of financing mechanisms for submarine cables include direct foreign investment (DFI) financing, government credit agencies, commercial banks, vendor financing, documentary credits and down payments derived from the pre-radio frequency systems (RFS), and indefeasible rights of use (IRU) sales. Submarine cables can also be built via private investment, either by investment companies or, as it has been the case in the last few years, by companies that are not traditional telecommunication operators (e.g., Internet giants such as Facebook and Google, among others). Another model for accessing submarine cables is an open access model, where each Internet service provider (ISP) has the appropriate license for international capacity. This model works best when there is competition on national cables or wholesale access to the incumbent’s network at cost-based prices.

When it comes to technologies, in the case of inland cross-border networks, terrestrial fiber is the preferred technology. Satellite or microwave technologies are either too expensive or too limited in terms of capacity.

As with submarine cables, cross-border terrestrial cables can also be built via consortia or via stand-alone, single, or multiple stakeholder private investment, and financed by DFI. National optical fiber networks, on the other hand, constitute the backbone for telecommunication services in a country. They are designed to increase broadband coverage for the country's population and to increase the content that can be carried through. Broadband access to national networks can be reached via wired technologies such as optical fiber cable, and also via satellite and microwave technologies. However, satellite technologies present challenges in terms of speed and stability when covering national networks, and microwave is usually not suitable for deployment in high-speed backbone requirements.

For landlocked countries, the benefits of submarine cables are only realized when there is an available and affordable cross-border interconnection and strong national backbones. Landlocked countries that can develop cost-effective national backbones that connect with regional cross-border networks and submarine cables will take advantage of faster Internet connections with low-end user prices.

As with landlocked countries, small island states face significant challenges in Internet connectivity due to their location, high costs of open sea crossing, and small populations. To address their connectivity challenges, small island states might take advantage of nearby submarine cables planned for other destinations as long as there are policies and financing mechanisms established to help these countries raise the necessary funds. Sub-regional projects involving intraisland cooperation could also work by generating economies of scale that justify return on investment.

Business and financial models for national and cross-border networks are dependent on each other, and each presents different economical and technology features. The development of the right business and investment models, as well as of the financial tools to be used, depends on the roles the actors play. A business model's financial needs can be addressed by the state, by private entities or by sharing mechanisms. Management of backbone infrastructure is typically done by the state, private contractors, or private design, build, operate (DBO) actors.

Middle and last mile connectivity

The term middle mile is used for describing the network infrastructure that connects last mile/local networks to other network service providers, telecommunication carriers, and the Internet. In the middle mile, Internet is brought to a point in a community for further distribution; the typical distances for middle mile coverage goes from 10 to 100 km. In contrast, last mile is the term used to describe the infrastructure carrying signals from the middle mile along the relatively short distance (the last mile) to and from the home or business. Last mile distances range between one and five km.

Middle and last mile technologies can be grouped into wired and wireless solutions. Wired technologies include optical fiber and cable, and wireless technologies span from mobile broadband to microwave to satellite. Mobile technologies are becoming more dominant for broadband delivery as they are in principle fast and less costly to deploy. Wireless fidelity (Wi-Fi) is gaining popularity due to its ease of implementation and low cost. Microwave and satellite technologies are also popular for middle mile but not as fast and efficient as fiber, and in the latter case, costs and vulnerability—due to exposition to environmental conditions—represent an additional point of consideration. Some innovative solutions for addressing gaps in last mile connectivity include drones, balloons, and television white space (TVWS).

All these solutions are still at an early stage and have many unsolved challenges to guarantee sustained high-quality performance. Nevertheless, they deserve attention and close monitoring, as their technological evolution might represent a complementary way to solve connectivity problems.

For last mile, it is very important to share the costs of network deployment. Much of this is in the middle mile network and hence, "dig once" policies and passive infrastructure sharing are important for lowering costs. Sharing backhaul to the towers and tower sharing are also additional alternatives for sharing or lowering the costs. At the spectrum level, it is also important to lower costs. This can be done by designing spectrum tenders prioritizing its socioeconomic impact versus raising funds, as well as by allowing operators' flexibility in their usage of current spectrum allocations (e.g., reselling or leasing spectrum), rather than having to purchase new allocations. Explicit spectrum repurposing is also helpful to enable upgrades to new technologies.

In addition, it is important that adequate amount of spectrum is made available, and in the right spectrum bands. Likewise, spectrum auctions should not prioritize the maximization of government revenues at the expense of operator deployments. One model is to include coverage requirements in spectrum licenses. Other community deployment models discussed in further detail in the report include private-or-public DBO model, privately-run municipal network model, community broadband model, operator subsidy model, community funding, development bank (DB), Universal Service Funds (USF), and reverse and forward auctions.

Middle and last mile networks are built to complement international and national networks. These networks ultimately provide retail service to end-users. However, to promote last mile networks for end-users, it is also important to focus on the issue of demand. This includes ensuring the affordability of access, safeguarding access to relevant content and services, and building capacity to teach the skills needed to go online and be able to use content and services.

Best Practices and Lessons Learnt from Global and Regional Case Studies

In this report, two groups of case studies are presented. The first group, called role model countries, consists of Korea, Spain, and Estonia. These three countries have been selected for standing at the forefront or at a very developed stage in the deployment of their digital infrastructure, and for having used effective financing and regulatory frameworks as well as innovative technologies to achieve their goal. Additional criteria used for selecting these countries include the countries' readiness and digital momentum, their governance models, and the government's role in driving the design and implementation of open and comprehensive national broadband strategies.

There are many good practices, lessons learnt, and interesting approaches for the development of national and cross-border networks, as well as for increasing middle and last mile connectivity. Korea's success story can be linked to a combination of factors such as its economic turnaround, the government's clear vision for ICT, its political disposition, and decades of intervention and investment in education and modern technologies. Spain's case study highlights its success in fiber-to-the-home (FTTH) deployments, the importance of successful regulation, and the introduction of gradual but steady competition. The case study of Estonia calls attention to the role of government in developing and continuing successful policies, having smarter governance practices, and cooperating with the private sector for improving digital connectivity.

The second group of case studies is called LAC Deep Dive Countries and includes Ecuador and Chile. In the past years, these two countries have adopted meaningful policies that propelled them forward in their digital infrastructure strategy. From a digital perspective, these countries are at a very good momentum stage due to efforts made in driving an ambitious digital agenda forward to narrow the digital divide, and to improvements made in ICT infrastructure and market nature. Chile represents the opportunities made possible through successful policies, while Ecuador represents a country heading in the right direction.

Country Categorization Framework

This report presents a country categorization framework that examines the current situation of broadband connectivity and the regulatory environment for 26 countries in LAC, as well as for Korea, Estonia, and Spain. The framework plots these countries using IDB data from 2017,[1] in a three-by-three matrix across two axes, namely the horizontal axis or market concentration, and the vertical axis or broadband penetration.

The competitiveness of a market is modeled using the Herfindahl-Hirschman Index (HHI), and measures market concentration ranging from 0 (unconcentrated market) to 10,000 (highly concentrated market). Broadband penetration is measured as the number of broadband Internet lines (for both fixed and mobile broadband) per 100 inhabitants.

Across the fixed and mobile broadbands of the case study countries, Korea, Spain, and Estonia appear to be unconcentrated/moderately concentrated, but have high levels of broadband penetration. Ecuador and Chile are moderately concentrated and unconcentrated respectively and appear to exhibit medium/low levels of fixed broadband penetration. Ecuador is similarly characterized for mobile broadband, but while Chile still remains moderately concentrated/unconcentrated, it has moderate/high levels of mobile broadband penetration.

For fixed broadband, the country categorization results show that the best performers in the LAC region are Argentina, Chile, Costa Rica, Brazil, and Colombia. These five countries have an unconcentrated market and have achieved a medium level of fixed broadband penetration. Despite having a liberalized market, Bolivia, Honduras, and Paraguay, still fall behind their regional peers in terms of fixed broadband penetration. Barbados and Uruguay have achieved high penetration of broadband in spite of a highly concentrated market (see Tables A and B).

[1] Given the telecommunications market's dynamic nature, certain trends may have changed since 2017 and analyzing 2020 data may have triggered different results.

Table A. Fixed Broadband Penetration Versus Market Concentration

Vertical axis: Fixed broadband penetration / Horizontal axis: Market concentration	HIGHLY CONCENTRATED	MODERATELY CONCENTRATED	UNCONCENTRATED
HIGH	Barbados Uruguay	Estonia Spain	Korea
MEDIUM	Bahamas	Ecuador Mexico Panama Trinidad & Tobago	Argentina Brazil Chile Colombia Costa Rica
LOW	Dominican Republic Guatemala Guyana Jamaica Peru Venezuela	Belize Nicaragua Salvador	Bolivia Honduras Paraguay

Source: Authors' elaboration, based on data from IDB (2020).

For mobile broadband, the country categorization results show that the best performers in the LAC region are: Brazil, Chile, Costa Rica, Uruguay, and Bolivia. These countries have unconcentrated and moderately concentrated markets with high penetration rates for mobile broadband. Bahamas and Suriname have high penetration rates for mobile broadband despite having highly concentrated markets.

Table B. Mobile Broadband: Penetration Versus Market Concentration

Vertical axis: Mobile broadband penetration / Horizontal axis: Market concentration	HIGHLY CONCENTRATED	MODERATELY CONCENTRATED	UNCONCENTRATED
HIGH	Bahamas Suriname	Estonia Costa Rica Korea Bolivia Uruguay	Spain Brazil Chile
MEDIUM	Barbados Jamaica Trinidad & Tobago	Colombia Dominican Republic Ecuador Mexico Paraguay Venezuela	Argentina Panama Peru Salvador
LOW	Belize Guyana Honduras	Nicaragua Guatemala	

Source: Authors' elaboration, based on data from IDB (2020).

For the majority of the LAC countries studied in this report, there is still significant work to do in order to achieve universal broadband connectivity. Although there has been strong progress in mobile broadband penetration, increasing fixed broadband penetration remains a big challenge for the region, especially as this will require movement toward more liberalized and highly competitive markets, as well as a review of current policy frameworks (e.g., USF) and regulations to attract the capital investments that will be required by current and new stakeholders. This will be crucial if countries are to benefit from the technological advancements of the new decade, given the capacity, backhaul, and latency requirements that these technologies will necessitate.

Recommendations to Governments

Regardless of the type of market, governments must have a coherent vision, political will, and strong leadership when developing their broadband strategies and digital agendas. Thus, government intervention should be based on clear policy objectives and an open mindset toward developing a cooperative and trustworthy relationship with the private sector. Having specific and attainable targets for their national broadband strategies, an independent agency, open access, and diversified public and private funds are some of the guidelines at the general level.

This report introduces a series of recommendations specifically tailored to the market situation a country finds itself in. For governments with highly concentrated markets, key recommendations include the following:

- Liberalize the market to allow competition.
- Corporatize the incumbent and possibly privatize it (to allow investment).
- Develop an independent regulator with the capacity to impose assymetric measures to create a level playing field between the incumbent and competitors.

Countries with a moderately concentrated market could benefit from the following guidelines:

- Make entry feasible with license conditions, low costs, and transparent and straightforward procedures.
- Where competition is not feasible, regulate retail prices and allow cost-based access to incumbent’s facilities.
- Introduce timely and effective ex post competition controls to make sure there are no price squeezes or other anti-competitive actions.

For those countries where there is already an unconcentrated market, some of the recommendations include the following:

- Remove ex ante competition regulations (retail prices and cost-based access) where there is competition.
- Ensure ex post competition regulation to keep competition, including merger review.

This report also reviews a series of guidelines to extend access in middle and backbone, and propose the following:

- Ensure that all network industries—roads, railroads, electrical—can make their rights-of-way (ROW) available to telecom operators to build networks.
- If any network industries have their own fiber networks, promote their participation in the market by making it available on a wholesale level or on a retail level.
- Streamline ROW permits and encourage infrastructure sharing to lower the cost of deploying infrastructure.

For extending access in the last mile, recommendations include the following:

- Ensure that sufficient spectrum is available for operators at a reasonable cost, in spectrum bands that are internationally recognized and have available equipment and devices.
- Include coverage requirements into the spectrum licenses, which may lower the returns from the spectrum, but could result in efficient coverage of new areas.
- Allow tower sharing to save on the cost of deployment.
- Use USF to expand coverage and making infrastructure available to all operators.
- Improve coordination between central and federal government agencies and other actors, including local governments, for the efficient deployment of broadband networks.
- Introduce mapping tools and funding network-mapping initiatives.
- Allocate money to finance initiatives for community networks and rural connectivity.

As important as dealing with the supply side of the issue, specific measures and guidelines must be followed and put in place to address the demand side of the problem. Governments also need to make sure their populations have access and can truly benefit from high-speed broadband networks. Though not the primary focus of this report, some of the initiatives to advance progress on the demand side include the following:

- Encourage digital and literacy skills' education throughout the educational system.
- Find local champions to address reluctance to change behaviors and help embrace technology and the Internet in rural communities.
- Promote content that is in the local language(s) and relevant to local residents.
- Attract international platforms to be hosted locally.
- Remove high taxes on devices and services.
- Ensure trust and security in the use of ICT through legislation that protect users.
- Promote e-commerce, e-government, and a digital economy.

A holistic, inclusive, and innovative approach is urgently needed to ensure that all the benefits broadband brings also reach the most vulnerable and marginalized populations.

Introduction

Strategies and Business Models for Improving Broadband Connectivity in Latin America and the Caribbean

Guidelines for the Planning, Investment, and Rollout of Broadband Networks

Introduction

Being able to connect to the Internet has become as important as having access to electricity, water, or transportation. Recent research has demonstrated that digital infrastructure, including the Internet, has a fundamental impact on a nation's economic development and productivity as key enablers for education, health, employment, as well as environmental and agricultural programs (García Zaballos, Iglesias and Adamowicz, 2019). Econometric models from institutions such as the IDB show that in LAC, on average, a 10 percent higher broadband penetration is associated with 3.19 percent higher gross domestic product (GDP), 2.61 percent higher productivity, and 67,016 new jobs (García Zaballos and López Rivas, 2012). These figures also show that the greater the fixed broadband penetration in LAC the higher the impact its expansion will have on GDP growth. Aware of the positive impact of broadband technologies in a country's economic development, the United Nations (UN) has made Internet connectivity and Internet affordability one of its key pillars in their 2030 Agenda for Sustainable Development, with the international community committing to "significantly increase access to information and communications technology and striving to provide universal and affordable access to the Internet in least developed countries by 2020" (ITU, 2018a: vi).

Notwithstanding the global awareness around the importance of Internet connectivity, and worldwide progress in making Internet available, today about 46.4 percent of the world's population (i.e., 3.6 billion people) live without Internet access, 90 percent of whom reside in developing countries (ITU, 2019a). According to the International Telecommunications Union press release (ITU, 2019b), as per 2017, 22.8 percent of the population in the American continent had no Internet access. Many of these people live in rural and hard to reach areas with little to no access to any type of basic infrastructure. They also face gaps in literacy and skills, and disparity in income. Gaps in regulatory frameworks and gender and social barriers also aggravate the problem.

Investment in international connectivity infrastructure is critical as it increases the amount of international Internet bandwidth available in a country and the quality and speed of its networks. However, the main focus to date has been on connecting major cities with highly populated areas and large number of households and businesses due to a higher and faster return on investment for operators and governments.

Internet connectivity in the rural and more remote areas remains a challenge for many countries. This is not only due to lack of investment but also of viable business models. Furthermore, on the demand side of the problem, more consistent and integrated efforts are needed in order to increase skills levels of target populations, the availability of localized content, and awareness of the importance of connectivity for everyday life.

LAC lag far behind developed ones in broadband penetration, household access to ICT, and Internet adoption. The Broadband Development Index (Indice de Desarrollo de la Banda Ancha, or IDBA) is a powerful tool to identify the magnitude of the gap by using two different geographic approaches. On one hand, it compares the state of the art of one country versus the cluster region the country belongs to, and on the other, it compares the country under analysis with respect to the OECD countries. According to this index, for example, OECD countries rate an average of 6.14 (on a scale from 1–8), while the average of the 25 countries in the LAC region scored 4.37, with Chile (5.57), Barbados (5.47), and Brazil (5.32) in the forefront. The IDBA relies on a comprehensive approach based on four pillars: infrastructure, applications and capacity, strategic regulations, and public policy and strategic vision. Those four pillars are built as a result of the combination of 47 indicators from renowned international institutions. For the IDB, efforts to increase broadband access would help LAC countries and their governments not only to address their most pressing development challenges, but also to pursue the opportunity to “leap forward” into providing the foundation for an advanced digital-based economy.

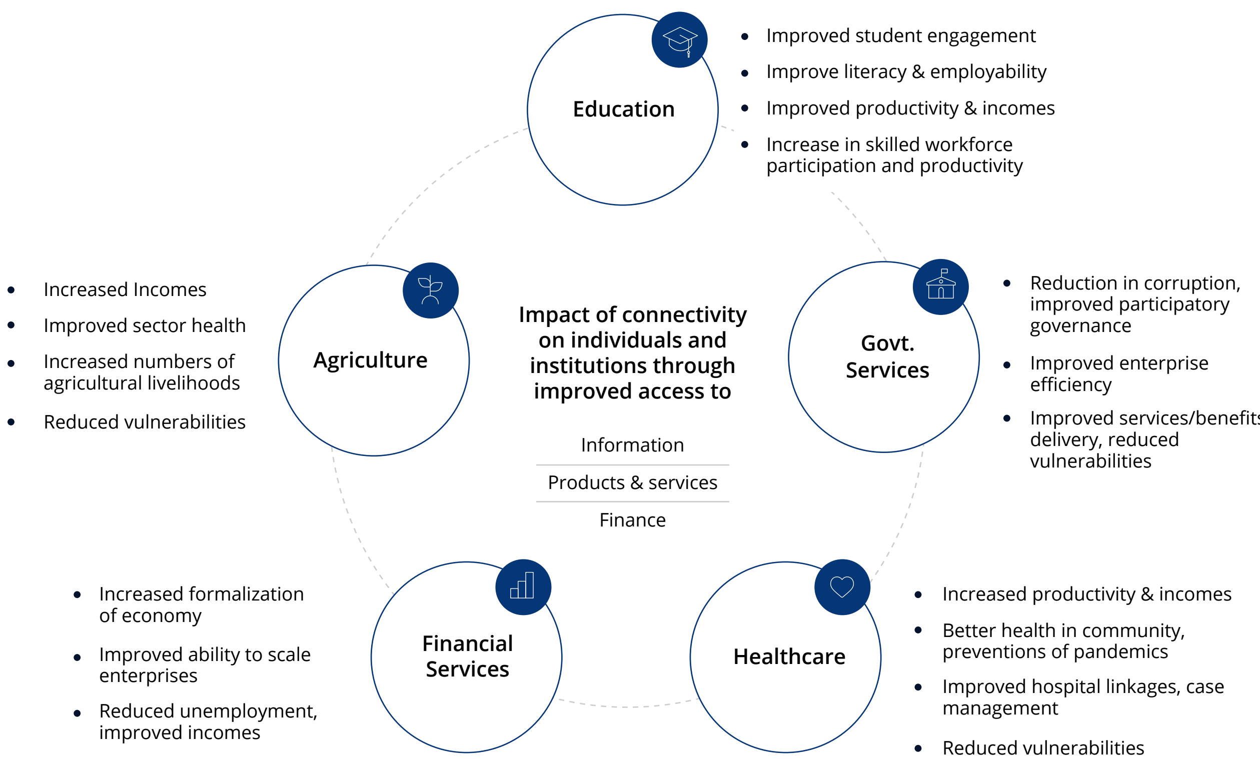
The Case for Connectivity

The marvels of the Internet and the opportunities it brings are not granted to everyone. In many places of the world, particularly in least developed and developing economies with low-income, marginalized, rural and remote communities, the challenges in connectivity are not only related to availability and affordability, but also to literacy, relevance, and cultural norms. In its Internet For All initiative, the World Economic Forum (WEF) highlights, among key barriers to achieving universal Internet connectivity, the skills of awareness and cultural acceptance, as well as local adoption and use of Internet. A recent report from the United States Agency for International Development (USAID, 2019) entitled Investing To Connect also brings to the forefront the issue of local content as well as socio-cultural and gender-based gaps, especially in poor and marginalized communities. According to this report, approximately 80 percent of online content is only available in 10 languages, which represent the first language for only about three billion of the world's population. The report also uncovers that women are 26 percent less likely than men to use mobile Internet in low and middle-income markets. However, closing the gender gap in mobile ownership could generate up to US$15 billion over the coming year alone for providers.

Other reports, such as IDB's Impact of Digital Infrastructure on the Sustainable Development Goals (García Zaballos, Iglesias, and Adamowicz, 2019), and the reports by Alliance for Affordable Internet (A4AI)'s Meaningful Connectivity Standard (A4AI, 2020a) and Rural Broadband Policy Framework (A4AI, 2020b) also highlight the importance of investing in digital infrastructure to help close the gaps on gender parity, education, employment, agricultural sustainability, food security, and spatial inequality in 12 countries in LAC. In these reports, it is also explained how investing in digital infrastructure can help close the gaps between the region and the OECD countries. Complementary research and scientific evidence show that connectivity can have a positive impact on employment and earnings: it is estimated that equalizing Internet access between developing and developed economies could lead to 140 million new jobs and could create up to US$2.2 trillion in GDP (UNDP, 2016).

Thus, the collateral impact that Internet connectivity can have in the economy, especially in least developed nations, is huge (Qiang, Rossotto and Kimura, 2009). It can affect positively the performance of all sectors starting from agriculture, education, financial services, healthcare, economy, and government service delivery (see Figure 1).

Figure 1. Multi-Sectorial Impact of Connectivity



Source: USAID (2019).

In agriculture, for example, access to connectivity allows farmers and field workers to obtain the information they need on crops and supplies on a real time basis. It allows them to increase revenues by reducing price dispersion in local markets (World Bank, 2016), and to communicate and create communities of knowledge where to ask questions, share information, and discuss issues. The World Bank's (2016) Digital Dividends report highlights the efforts of organizations such as Digital Green, the Grameen Foundation, and TechnoServe to deliver timely, relevant, and actionable information and advice to farmers in South Asia, Latin America, and Sub-Saharan Africa respectively, at a dramatically lower cost than traditional services.

Rather than always visiting a farmer, extension agents use a combination of phone calls, text, videos, and Internet to reduce transaction costs and increase the frequency of interaction with farmers. Governments, in partnership with mobile operators, use phones to coordinate distribution of seeds and subsidized fertilizers in remote areas through e-vouchers, as in Nigeria's e-wallet initiative (World Bank, 2016: 90).

In regard to education, connectivity increases access to a world of additional learning resources for students and teachers alike, as well as for parents and relatives. It also develops human capital by directly contributing to the enhancement of skills, employability, and entrepreneurship.

There is significant evidence of many successful projects around the world that use technology to increase the quality of education provision and that impact curricula, the effective use of IT devices in school settings, pedagogical tools for supporting the teacher's profession, as well as evaluation and monitoring mechanisms that go beyond outputs (World Bank, 2016).

With respect to financial services, inclusion of people with no access to banking resources can also be achieved through enhanced connectivity and access to services and tools such as mobile money and digital wallets. According to the World Bank's Digital Dividends (2016) report, more than 2 billion people have no access to any financial services and only about 59 percent of men and 50 percent of women in developing countries have an account at a regulated financial institution. Online connectivity and digital payments can help overcome barriers to accessing financial services and improve the process of remittances. For otherwise unbanked people, having online access to financial services also helps lowering the risks of theft (USAID, 2019).

Another sector where the benefits of connectivity are often more visible is healthcare. Mobile Internet connectivity has the potential of increasing health system efficacy through digital health. Online health applications can be used to improve maternal and newborn health, as well as for countries to better understand and manage chronic diseases such as diabetes and HIV affecting their population. It also helps countries and international health organizations to have better and quicker reactions to pandemics. Moreover, through digitization of healthcare records, physicians can also have a more detailed yet holistic picture of a patient's clinical history, which enables them to provide better treatment options.

All these improvements in productivity and human capital have in turn a positive impact on the economy. Connectivity reduces transaction costs and enhances labor productivity. Having access to the Internet enables farmers, small business owners, and entrepreneurs to access new markets, get advanced training and connect to other businesses and communities. It also allows minorities and women to contribute to the economy and exert their social rights. The impact of connectivity on women can cascade into other outcomes. For example, removing obstacles to gender parity could contribute directly to creating an estimated US$28 trillion worth of new global value in a decade, with US$2.6 trillion coming from the LAC region (Woetzel et al., 2015).

Lastly, connectivity has also a critical role to play in government service delivery. Connectivity can help to improve the efficacy of the services and reduce costs, thanks to the elimination of unnecessary processes and bureaucratic hurdles. Connectivity has enabled government agencies not only to reduce transaction costs, but also to come closer to their citizens by engaging them into a truly democratized decision-making process. Connectivity can overcome geographic barriers thus serving as an important inclusion tool for citizens living in remote areas who otherwise would have to travel very long distances to exert their fundamental civic rights and duties and to receive government services or aid.

Purpose and Structure of the Report

In the past five years, the IDB has dedicated significant resources and efforts to research and address the issue of digitalization. The organization dedicates an average of US$2 million every year on grant-financed technical cooperation efforts. These include initiatives such as the Center of Advanced Studies on Broadband Development (Centro de Estudios Avanzados en Banda Ancha para el Desarrollo, or CEABAD), the digiLAC platform, and networks such as the Broadband Environment for Sustainable Transformation (BEST). Through BEST, the IDB hopes to provide policy makers and communities in the region with information resources about good practices, financing models and new trends, as well as with a focal point for dialogue on broadband development and digital infrastructure.

This report is part of the IDB's effort to drive change on digital infrastructure in the region, thereby helping countries improve their indicators on connectivity. Its objective is to compile and analyze global business and financial models, best practices, innovations, and progress around the topic of digital infrastructure, including middle and last mile connectivity. It also aims at serving as a guidance tool for policy makers, regulators, government officials, as well as private sector and community leaders in the LAC region, to better assess alternatives for improving broadband connectivity, and tailor best practices and approaches to their own country's needs.

The report is structured around six chapters. The introduction presents the case for connectivity and explains the framework used for country categorization as well as the criteria used for the selection of the five countries chosen as the case studies: Korea, Spain, and Estonia, Ecuador and Chile. The chapter also provides an introduction to broadband connectivity networks, policies, and regulation.

Chapter one presents some of the technologies, business and financing models, good practices and lessons learnt from international, cross-border, and national networks, and discusses how they can be applied to the LAC context. The scope of this report does not include a full analysis of these networks but rather provides a general overview of the issues and implications that cross-border connectivity might have in terms of regional integration. The chapter also outlines general challenges for landlocked countries and some approaches for the deployment of broadband networks despite their geographical constraint. A small section on island states, as well as their general challenges and opportunities for achieving Internet connectivity is also included.

Chapter two examines innovative technologies, business models, good practices and lessons learnt for middle and last mile Internet access with a deep dive on the potential applications for the LAC context.

Chapter three presents the collection of the five case studies that conform the core of this report. These are divided in three global case studies, namely Korea, Spain, and Estonia, and two LAC case studies: Ecuador and Chile. It shows the technologies, business and financial models used by these countries, as well as key success factors, lessons learnt, policy frameworks, and future opportunities for national, cross-border, and middle and last mile networks.

Chapter four introduces the results of the country categorization framework, as well as a brief analysis of the technologies and trends impacting the networks of the future. The core of the chapter is the detailed compilation of recommendations, guidelines and options to policy makers, public and private stakeholders in LAC, including the members of the BEST Network, for extending backbone broadband networks, as well as rural/last mile access. This chapter intends to provide policy makers with enough criteria and tools to assess business models for broadband infrastructure deployment in rural areas and tailor successful strategies and lessons learnt to a country's given circumstances.

Chapter five compiles as annexes, additional charts and tables that support and expand the information presented in this report.

Country categorization framework

This report examines the current situation of broadband connectivity and regulatory environment in LAC. The information is presented in two figures: fixed broadband connectivity (see Figure 4.1) and mobile broadband connectivity (see Figure 4.2). While the figure for fixed broadband connectivity analyzes 24 countries from LAC and compares them with the three global cases of Korea, Spain, and Estonia, the figure for mobile broadband connectivity does the same but with 25 LAC countries. This analysis has been done based on a Country Categorization Framework developed with the research support of the Center for Technology, Innovation, and Competition at the University of Pennsylvania. The framework can be used in conjunction with the guidelines and recommendations presented in Chapter 4 to identify the stage of digital development a country finds itself in, and what are the suggested actions that could help it move to a more advanced stage.

The Country Categorization Framework plots 24–25 LAC countries, as well as Korea, Spain, and Estonia using data collected in 2017 in a three-by-three matrix across two axes, namely the horizontal axis or market concentration (see Table 1) and the vertical axis or broadband penetration (see Table 2).

The competitiveness of a market is modeled using the HHI, which is the most commonly used index to measure market concentration. The competitiveness of a market is calculated by squaring the market share of each firm competing in a market and then summing the resulting numbers.

The result is a measure of market concentration ranging from 0–10,000, with 0 representing perfect competition and 10,000 representing monopoly.[2] Broadband penetration is measured as the number of broadband Internet lines (for both fixed and mobile broadband) per 100 inhabitants. Both the HHI and broadband penetration data are taken from the IDBA 2018 Annual Report (García Zaballos and Iglesias, 2018).

Table 1. Horizontal Axis: Market Concentration

MARKET CONCENTRATION	DESCRIPTION
Highly concentrated	A market's concentration level is classified as high when the HHI is greater than 5,000. This cutoff represents the level of competition that would exist in a market consisting of two equally sized firms.
Moderately concentrated	A market's concentration level is classified as moderate when the HHI is between 3,333 and 5,000. As noted above, the upper cutoff represents the level of competition that would exist in a market consisting of two equally sized firms. The lower cutoff represents the level of competition that would exist in a market consisting of three equally sized firms.
Unconcentrated	A market's concentration level is classified as low when the HHI is below 3,333. As noted above, this cutoff represents the level of competition that would exist in a market consisting of three equally sized firms.

Source: Authors' elaboration.

Using the level of competition associated with a market of three equally sized firms as the cutoff for defining when market concentration is low may help us track the enforcement practices of global competition law enforcement authorities, who often approve mergers that reduce the number of firms in the industry from four to three. Using the level of competition associated with a market of two equally sized firms as the cutoff for defining when market concentration is moderate similarly tracks enforcement practices, as authorities do not routinely approve mergers that reduce the number of firms from three to two competitors, but sometimes allows them to proceed. The fact that enforcement officials rarely permit two-firm industries to merge into monopolies justifies using 5,000 as the cutoff for treating market concentration as high.

[2] Given the relative concentration of broadband markets, the framework bases the HHI on the market shares of the four largest firms; in many cases there are only four or fewer providers.

Table 2. Vertical Axis: Broadband Penetration

STAGE	DESCRIPTION
Low penetration	Penetration for fixed broadband is classified as low when the number of fixed broadband lines per 100 inhabitants falls between 0 and 10. Penetration for mobile broadband is classified as low when the number of mobile broadband lines per 100 inhabitants falls between 0 and 40.
Moderate penetration	Penetration for fixed broadband is classified as moderate when the number of fixed lines per 100 inhabitants falls between 10 and 25. Penetration for mobile broadband is classified as moderate when the number of mobile broadband lines per 100 inhabitants falls between 40 and 70.
High penetration	Penetration for fixed broadband is classified as high when the number of fixed broadband lines per 100 in habitants exceeds 25. Penetration for mobile broadband is classified as high when the number of fixed broadband lines per 100 inhabitants exceeds 70.

Source: Authors' elaboration.
Note: The cutoffs for high, moderate, and low broadband penetration follow the thresholds commonly used in literature.

Selection of country case studies

Throughout the chapters of this report, two groups of case studies will be presented. The first group is also called role model countries and they represent the global case studies of Korea, Spain, and Estonia. These three countries have been selected for standing currently at the forefront, or at least at a very developed stage, in the deployment of their digital infrastructure, and for having used effective financing and regulatory frameworks as well as innovative technologies to achieve this goal.

Additional criteria used for selecting these countries include: the countries' readiness and digital momentum, its governance model, and the government's role in driving the design and implementation of open and comprehensive national broadband strategies.

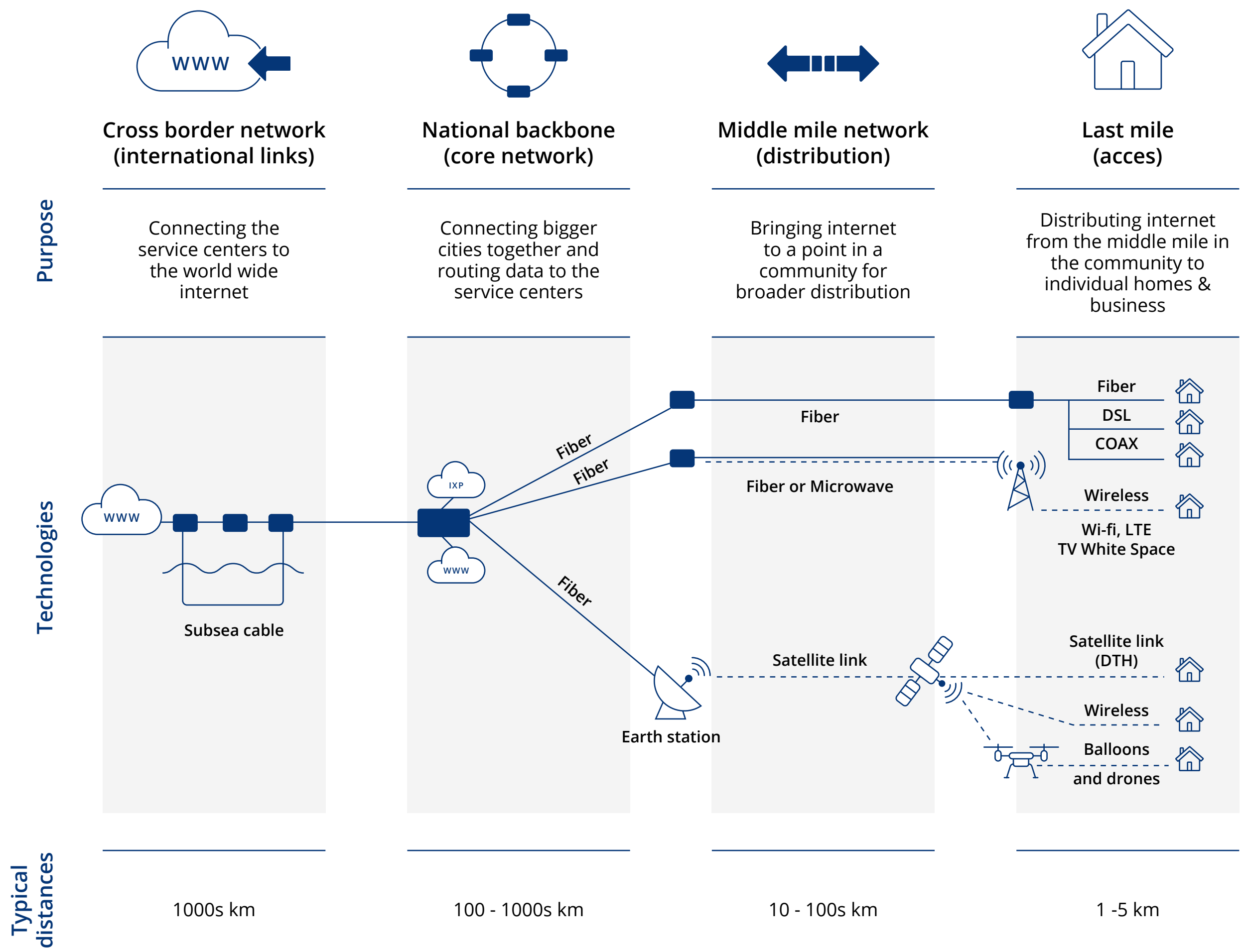
There are many good practices, lessons learnt, and interesting approaches for the development of national and cross-border networks, as well as for increasing middle and last mile connectivity that can be drawn from the three role model countries and applied to the LAC context. The case study on Korea, for example, highlights a combination of factors such as its economic turnaround, the government's clear vision for ICT, its political will and decades of intervention and investment in education and modern technologies. Spain's case study stands out because of its success in FTTH deployments, the importance of successful regulation, and the introduction of gradual but steady competition. Lastly, the case study on Estonia calls attention to the role of government in developing and continuing successful policies, having smarter governance practices, and cooperating with the private sector in order to improve digital connectivity.

It must be noted that while there are stark differences in terms of demographics, culture, geography, size, or other factors between the role model countries and those of LAC, this report looks at the three cases of Korea, Spain, and Estonia for insights on successful regulatory and financing frameworks that can be tailored and adapted to the situation in LAC countries. Moreover, the report also reviews several LAC countries for insights closer to home. Such is the case of the second group of case studies, called LAC Deep Dive Countries, which focuses on regional case studies with attention to Ecuador and Chile. In the past years, these two countries have adopted innovative policies that propelled them forward in their digital infrastructure strategy. From a digital perspective, these countries are at a very good momentum stage due to efforts made in driving an ambitious digital agenda forward to narrow the digital divide, and to the improvements made in ICT infrastructure and the market nature. Chile represents a country enjoying the opportunities of digitalization thanks to implementing successful broadband policies, while Ecuador represents a country heading in the right direction.

Networks and infrastructure

This report examines network deployment for international, cross-border, and national networks as well as for middle mile and last mile networks. While there are differences in the approach required by these types of networks, there are also significant similarities in terms of technology and regulation. We address the similarities here, and then the separate parts of the network in Figure 2.

Figure 2. Network Infrastructure, Technologies, and Reach



Source: World Bank (2019).

Technology and business models

Despite its deployment and implementation costs, optical fiber is today the best type of technology for providing fastest and uninterrupted transmission over long distances in international, in-land cross border, and national networks. There is a growing demand for broadband infrastructure which fiber covers well with good quality results for end users.

Optical fiber consists of glass fiber cables encapsulated in resistant material, which operate by dispersing pulses of light among them. Distribution of signal works by electrically powered network equipment or unpowered optical splitters. The connection speed might vary depending on the type of glass used in the cable's manufacturing process.

Long-haul optical fiber networks need to carry vast amounts of information across different geographic conditions: under seas, over mountains, coast to coast, through deserts and forests. This is the reason why building a long-haul national network is not only expensive but also challenging; these networks range from hundreds to thousands of kilometers and have migrated to 100G-based dense wavelength division multiplexing (DWDM) systems with 80 or more channels. DWDM occurs when many different data signals are transmitted at the same time, through the same optical fiber.[3] The advantage is that the DWDM equipment can be upgraded for higher capacity, if the optic fibers support such increases.

Last mile networks are also increasingly using optical fiber, particularly for new greenfield builds, as they have the highest capacity and the cost of the civil works is the same as for laying earlier technology, notably copper. Typical download speeds for an optical fiber Internet connection go between 150 Mbps and 500 Mbps. Upload speeds can be as high as 65 Mbps and a maximum of 100 Mbps. This allows users to upload and download data, stream videos, and share files without sacrificing performance (Smith, 2019).

Where there is already copper, optic fiber can be put further and further into the network, to increase the speeds without the cost of replacing last mile networks. Mobile networks are also used for last mile broadband and, with increases in capacity through recent generations—in particular, in view of the coming fifth generation wireless telephone technology or 5G—, the speeds are beginning to approach what fixed broadband can provide, with lower deployment costs. It is important, however, to connect the towers with fiber backhaul to accommodate the traffic and speeds that 5G will generate.

Optical fiber networks are highly upgradable if greater speeds are required in the future. Once the basic optical fiber infrastructure is in place, it can be rearranged and upgraded to deliver even higher capacity. Recent research in the United Kingdom has pushed the transmission speed for large volumes of data in glass optical fibers from below 70 percent to 99.7 percent of the optimum speed of light in a vacuum; this shows that current optical fibers have reached a very mature state (Bouwfonds, 2017).

For all network deployments, considering new technologies, it is important to break down the networks into layers. Overall, passive infrastructure is the building block for networks, while connectivity is provided by applying active components to the passive infrastructure; the active components allow services to be provided. As such, models for competition in dense areas, and for deployment in rural areas, can treat passive infrastructure separately from active infrastructure, more specifically:

[3] DWDM systems and fiber amplifiers have made the need for light path integrity more critical. Careful choices in fiber type, cable design, and optical connectivity can make the difference in performance, cost and long-term integrity of the light path.

- Passive infrastructure includes ducts for optical fibers, towers for mobile antennas, and ROW or electricity poles from railroad or electric utilities along which networks can be deployed.
- Active infrastructure includes smart telecommunication and Internet equipment that is used to transmit signals through the passive layer.
- Services can include broadband or internet protocol (IP) transit service through the international or national backbone.

The separability of networks leads to two different models for deployment and offering services, namely, the vertically integrated model and the open network model. The vertically integrated model is the standard for telecommunications service provision. In it one actor takes all three roles (e.g., large telecom operators, which own the passive and active infrastructure and offer services to end users). In addition, operators could also offer access to competing service providers at the wholesale level. Submarine cables were historically vertically integrated, although more recently with competition and new cables, wholesale services are being made available to independent operators. National networks are also traditionally vertically integrated, but again separation is being introduced.

With respect to last mile, vertically integrated actors have rolled out the vast majority of broadband infrastructure in the world. Mobile Network Operators (MNO) have thus transformed the landscape of ICT in developed and developing countries. This business model is associated with complex operations and high execution risks. Therefore, they are better suited for markets with robust infrastructure competition.

For new builds, particularly with government resources, vertically integrated models are not recommended.[4] For one thing, this type of model is not well suited for countries where anticompetitive behavior is not regulated. For another, it is important to enable competitors to compete on a level playing field with respect to infrastructure access. Another advantage is that there is no replicated infrastructure.

In contrast, in the open network model roles are separated and the infrastructure is open to all market participants at equal conditions. In European models, this includes three possible variants: passive layer open model (PLOM), active layer open model (ALOM), three-layer open model (3LOM) (EC, 2015). This report discusses general models that include at least one layer of network sharing or access.

As noted below, there may be differences in the deployment models for international, cross-border, and national networks as opposed to middle and last mile networks. One critical difference is that the latter networks are used to provide retail services to end-users, while the former may be made available to providers as wholesale services. Notwithstanding in each case, there are ways to share the infrastructure at the passive or active layers. Part of this results from regulations.

[4] For existing networks, if it is not a new built, it is harder to separate, even if it is the incumbent. It is much easier to separate for something newly built with government money.

Policy and regulations

If countries want to achieve universal broadband access whilst enjoying open, agile, and competitive markets, private sector investments should be maximized so governments can focus resources where there is not likely to be any private sector interest. The present section discusses what such government involvement would imply in relation to each segment of the network.

First, the report examines the commonalities of several national government initiatives for promoting investment. The first step to promote investment is to enable competition and investment through sector reform. The second is removing barriers to investment and lowering the cost of deployment.

Sector reform is necessary, but not sufficient, to enable competition and investment. It involves corporatizing the incumbent, liberalizing the market for competition, and setting up a separate regulator. However, restrictions may remain, notably with regards to licensing. There should be no limit on the number of licenses, except with respect to scarce resources such as spectrum licenses for mobile services. Even there, mobile virtual network operator (MVNO) licenses can enable entrants to use the spectrum of licensed MNO.

To remove the barriers for deployment at all levels of network, access to ROW is critical. These can be facilitated with national procedures for access, at cost-based prices, whether on public or private land. This could happen with the purpose of deploying ducts or poles and towers for optical fiber, and it can be for towers for mobile services. Where investment is not likely, at least in the short term, wholesale access to the incumbents' network (particularly submarine landing stations and national backbones), should be facilitated at cost-based wholesale rates.

To lower the cost of deployment, a variety of approaches can be implemented. First, it is important to properly map existing infrastructure, in order to take advantage of existing network ROW, including railroads, electric transmission and distribution lines, as well as highways. If those utilities have their own fiber networks, access to those should be facilitated. For new deployments, a 'dig once' policy whereby any construction projects, such as road building, are announced in advance so that passive infrastructure can be deployed in the most efficient way possible. At the same time, operators should be encouraged to share at least passive infrastructure, such as ducts for fiber, or poles and towers for mobile antennae, in order to lower the costs.

There may still be areas where investment is not commercially viable, and here governments should focus their attention and resources. Where possible, this should be done in a liberalized way, to encourage efficient deployment of the resources with competitive access.

1. International, Cross-border, and National Networks

Strategies and Business Models for Improving Broadband Connectivity in Latin America and the Caribbean

Guidelines for the Planning, Investment, and Rollout of Broadband Networks

1. International, Cross-border, and National Networks

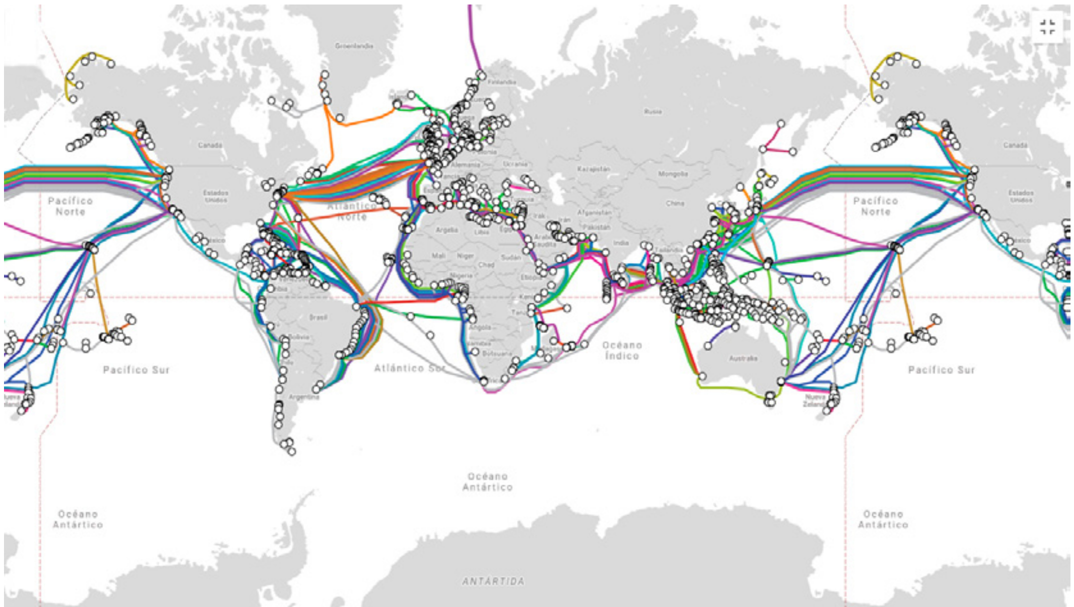
Although the scope of this report does not include a full analysis of international, cross-border, and national networks, this chapter covers some of the technologies, business, and financing models used worldwide for deploying international, cross-border and national networks, as well as the issues and implications cross-border connectivity might have in terms of regional integration. The chapter also examines general challenges for landlocked countries and presents some approaches for the deployment of broadband networks in these countries despite their geographical constraint. A section on small island states, as well as their general challenges and opportunities for achieving Internet connectivity, is also included.

International and Cross-Border Networks

International and cross-border infrastructure allows national networks of two or more countries to connect. This connection can be made either via subaquatic or terrestrial optical fiber cables. When connecting continents or covering long distances, submarine cables are used. These can be supplemented by terrestrial cross-border connections, to link neighboring coastal countries to create alternate routes, as well as to connect landlocked countries to the coasts.

Improvements in fiber technology and increases in demand have generated a massive growth in the number and capacity of submarine cables. According to the TeleGeography website (2020), at the beginning of 2019 there were approximately 378 submarine cables in service around the world (see Figure 1.1). They stretch over 1.2 million km around the world connecting different continents and subcontinents, transmitting about 90 percent of global data, and supporting US$10 trillion in international transactions every day. The longest submarine cable in service today is SEA-ME-WE3; it is 39,000 km long and connects the regions of South East Asia, the Middle East and Western Europe. It uses wavelength division multiplexing (WDM) technology with synchronous digital hierarchy (SDH) transmission for increased capacity and high-speed transmissions.

Figure 1.1. World Submarine Cable Map



Source: TeleGeography (2021).

In the case of LAC, the vast majority of submarine cables that connect the region run through the United States, with Miami still serving as the main hub (Rebatta, 2017). In July 2019, Chile started to accept bids for a feasibility study on the first optical fiber cable to run between Asia and South America (van der Speck, 2019); in September, the Under-secretariat of Telecommunications (Subsecretaría de Telecomunicaciones, or SUBTEL), Chile's telecommunications regulator, awarded the study to the Telecommunications Management Group (TMG) and WFN Strategies (Bnamericas 2019c). The US$3 million study will be financed by Chile's Transportations and Telecommunications Ministry together with the Development Bank of Latin America (Banco de Desarrollo de América Latina, or CAF) (Bnamericas, 2019a), and will research the technical, legal, financial, and economic parameters of the project. This transpacific optical fiber cable will run for approximately 24,000 km, with a throughput capacity of 10–20 Tbps over 4–8 pairs, and will cost an estimated US$650 million. It will be built and run as a public–private consortium for 25–30 years, and it will connect the country with Japan, or with Shanghai in China. Other countries in Latin America such as Argentina and Brazil have also expressed interest in joining the project. In 2017, Huawei and NEC presented pre-feasibility studies, which included the assessment of potential routes across the Pacific Ocean; Huawei is already deploying an optical fiber cable that connects Chile's northern and southern regions. The IDB is also financing a feasibility study for the construction of a submarine cable connecting South East Asia to Latin America (Chile, more specifically), with possible landing points in Singapore, South Korea, or Japan. There are several ongoing submarine cable projects run by private and state telecommunication operators, independent connectivity providers, and Internet companies, which aim at connecting Latin American countries to other regions and between themselves. Box 1.1 summarizes some of the more prominent ones.

Box 1.1. Most Prominent Latin American Submarine Cables

CONNECTING LAC TO THE UNITED STATES:

CURIE

Submarine optical fiber cable 10,000 km long that connects Los Angeles in the United States with Valparaiso in Chile. The cable is owned and managed by Google. In the medium-to-long term, the project seeks to connect to Google's data center in Quilicura, Santiago, and also gain access to Central America through Panama. Google is also involved in Latin America through other three projects: Monet, Tannat, and Junior. Monet connects Brazil with the United States; Tannat has landing points in Argentina, Uruguay, and Brazil; and Junior connects the coasts of Rio de Janeiro and Sao Paulo and it is operated exclusively by Google.

MEXICO

The Mexican telecommunications company Megacable has invested about US$23 million in this project aimed at connecting Sinaloa state in Mexico with Baja in South California, United States. Huawei's submarine cable division is in charge of building the 250 km optical fiber cable.

CONNECTING LAC TO AFRICA:

SAIL

The South Atlantic Inter Link (SAIL) is a project developed by a joint venture between China Unicom and Cameroon's Camtel with Huawei Marine running the execution. Launched in September 2018, this is a 6,000 km submarine cable with a capacity of 32 Tbps that connects Fortaleza in Brazil with Kribi in Cameroon. Future plans for the cable include potentially connecting all the BRICS countries: Brazil, Russia, India, China, and South Africa.

SACS

The South Atlantic Cable System (SACS) started functioning in September 2018 with landing points in Fortaleza, Brazil and Sangano, Angola. It was the world's first submarine cable across the South Atlantic Ocean. This is a 6,165 km long cable with an initial design capacity of 40 Tbps. It is owned by Angola Cables, which is a joint venture involving five Angolan operators.

SABR

Expected to launch in 2021, it will connect Brazil to South Africa with landing points in Recife and Cape Town. It will connect with the Seabras-1 cable in Northeast Brazil, enabling the most direct route between South Africa and the United States via Brazil. It is owned by Seaborn Networks.

CONNECTING LAC TO EUROPE:

ELLALINK

Today, 85-90 percent of Latin America's communications to Europe run on submarine cables through the United States. The only existing cable between Latin America and Europe, ATLANTIS-2, was built in the year 2000 but it is based on ageing technology. Currently, the ELLALINK cable is under construction by Alcatel Submarine Networks, with four pairs of optical fibers and an estimated capacity of 72 Tbps. It is expected to become operational in January 2021 and it will link Latin America (Brazil) with the European Union (EU). The cable will run over 10,000 km and will connect the cities of Sao Paulo and Fortaleza in Brazil to data centers in Lisbon, Portugal and Madrid, Spain. Inside Latin America, extensions will be made to bring Uruguay, Paraguay, Argentina, Chile, Peru, Ecuador, and Colombia into the same network. A Memorandum of Understanding (MoU) was signed between Telebras and EuraLink in 2012 and a Joint Venture was created in 2015. The European Commission (EC) invested around US$28 million under the BELLA (Building Europe Link to Latin America) program. The focus is principally on sharing academic and scientific content.

ATLANTIS-2

Launched in February 2000 with the aim of connecting Europe to Africa and LAC, this 8,500 km cable is owned by a conglomerate of large telecom operators such as: Embratel, Deutsche Telekom, Telekom Italia, Telekom Argentina, AT&T, Tata Communications, and others. It has six landing points in Portugal, Spain, Senegal, Brazil, Argentina, and South Africa.

SUBMARINE CABLES FOR CONNECTING COUNTRIES WITHIN LAC:
AMX-TELXIUS

The 7,300 km long cable project was announced in June 2019. It aims to connect Guatemala (via Puerto San José) with Chile (Valparaiso), with multiple landing points in Salinas, Ecuador, Lurin in Peru, and Arica, Chile. The initial capacity is estimated at 108 Tbps and it is expected to be ready by the end of 2020. The project will be led and operated by America Móvil and Telxius. This will be the first cable aimed at connecting the Latin American region since 2001.

MALBEC

This 2,500 km long cable intends to connect Rio de Janeiro in Brazil with Las Toninas in Argentina. GlobeNet and Facebook own the cable. It is expected to be activated in the second quarter of 2021.

ARBR

This is a 2,700 km long cable connecting Argentina to Brazil. The cable will have a landing point in Praia Grande, Sao Paulo state, and will connect to Buenos Aires via a landing point in Las Toninas. This is said to be the first and only transoceanic cable for Argentina not controlled by a large incumbent telecom company. The cable is co-developed by Seaborne Networks and Argentina's Werthein Group.

Sources: Bnamericas (2019b); DIGIBYTE (2018); TeleGeography (2021); Qiu (2014).

In the past, submarine cables were owned and operated by telecom carriers forming a consortium of operators representing each country with a planned landing station. Traditionally, these were the incumbents of each country, but more recently competitive providers began to participate. Consortia are still one of the ways for financing and building submarine cables; in this modality, the companies involved in the consortia carry the totality of CAPEX associated with the project. Once the countries impacted are identified, the entities initiating the project will determine the appropriate number of landing points, create redundancies on multiple routes, reducing the cost of ownership and facilitating crossing of territorial waters (USAID, 2019).

Each of the members of the consortia receives an allocation of a given unit of capacity that goes in accordance with their investment participation. In some instances, consortium members can also be classified in tiers and provided with agreed upon discounts to incentivize them to increase their contribution and involvement. In these types of projects, each operator also contributes to the operational management (O&M) expenses according to their share of cable. Some of the financing mechanisms for submarine cables include: DFI financing, government credit agencies, commercial banks, vendor financing, documentary credits, and down payments derived from the pre-Radio Frequency Systems (RFS), and IRU sales.

Some success criteria to consider for deploying consortia-driven submarine cables include the following:

- Establishing the consortium with an appropriate balance between public (government/publicly listed companies) and private operators, which are also operators of terrestrial cables and/or members of other submarine consortia. Although this facilitates onward connectivity, it should be noted that it might constitute a barrier to international connectivity for other terrestrial cable operators not part of the submarine cable consortium. This issue though, can be covered by open access and licensing criteria.

- Establishing clear processes, objectives, roles, and responsibilities at project set up phase. This is particularly relevant in the case of large consortia with multiple players. Several factors can help to make sure that the consortia model can aid in the delivery of connectivity within the country. First, an open access model (as described on the next page) can ensure that there is capacity available on the cable for non-participants in the consortium. This must be tied with a licensing regime that enables those operators which are not part of the consortium to have the necessary license to be allowed to purchase and utilize this capacity.

Submarine cables can also be built via private investment, either by investment companies or by companies that are not traditional telecommunication operators. In the 1990s, entrepreneurial companies built many cables and sold off the capacity to users. In the last decade, large Internet content provider companies such as Google, Microsoft, Facebook, and Amazon have entered the game and are now major investors in cable. These companies are laying ultra-fast cables with very large capacities, such as the following:

- MAREA, a 6,605 km long cable connecting the United States with Europe (Spain) and owned by Microsoft and Facebook that is capable of transmitting 208 Tbps. It is currently the world's highest capacity submarine cable.

- DUNANT, a 6,400 km long cable spanning through the Atlantic Ocean, from Virginia Beach in the United States to the Atlantic coast of France. Google commissioned the 6,400 km long cable to add capacity and alleviate traffic in one of the busiest routes on the Internet. This transatlantic cable will transmit 250 Tbps of data and is the first cable made using space division multiplexing (SDM) technology. Its extraordinary capacity equates to transmitting the entire US Library of Congress three times every second (Li, 2019).

In the coming years we will continue seeing heavy investment in submarine cables from Internet giants such as the ones already mentioned (see Box 1.2). Facebook and Google, for instance, are expected to continue building new cables such as the Pacific Light Cable Network (in which both companies are investors), which will connect South East Asia (China, Philippines, and Taiwan) with the United States.

Box 1.2. Present and Future Investments in Submarine Optical Fiber Technology by Internet Content Providers

Global demand for submarine cable bandwidth grew 52 percent in 2017 to amount for 689 Tbps of total capacity. In the Atlantic and Pacific, content providers accounted for over half of the total demand in 2017. In the past ten years, content provider data use has increased from under 8 percent to near 40 percent. This is one of the reasons why large Internet content providers are directing their investments to submarine cables on routes that go across the Atlantic, as well as those which are Transpacific, intra Asian, toward Australia and South America. On cables entering service in 2019, Internet content providers such as Google, Facebook, Microsoft, and Amazon currently make up more than 50 percent of the investment in transatlantic routes and about a third on transpacific routes. Content providers also account for about 50 percent of the demand in the Atlantic, intra Asia, and transpacific routes, and are starting to have major shares on routes like Europe to Africa and Asia.

Spanning back to 2010, in total, Google has been involved in 13 submarine cable consortia and Facebook in at least eight. At present Google owns over 102,000 km (8.5 percent) of submarine cables worldwide. For Google, investing in submarine cable technology means investing in cloud infrastructure; it helps them provide better and higher quality services to customers and allows them to have more control of routing, latency, and guaranteed bandwidth over their established and future cloud regions. The company is investing more and more in financing their own cables instead of purchasing/leasing capacity on an existing one or building with a consortium.

FACEBOOK

Owns about 92,000 km (7.8 percent) of submarine cables worldwide. Facebook's interest in submarine cables comes from a lack of capacity. The company argues that the underlying submarine capacity is not sufficient for their activities and projects. Facebook uses two types of traffic, namely machine-to-machine and machine-to-user. The former of these involves data centers backing-up photos and posts on the social network and is six to seven times larger than machine-to-user traffic. Facebook’s biggest submarine project is JUPITER, a 14,500 km cable constructed in a partnership with Amazon connecting the United States with Asia.

AMAZON

Has relatively few submarine cable projects compared to Google and Facebook. The company currently owns 31,000 km of submarine cables (2.6 percent). All of their cables, including capacity purchases, run from the United States to Asia, connecting Japan and Singapore with the West Coast of the United States. Their involvement in submarine cables is also rooted in the capacity needs for supporting their cloud operations (AWS, Amazon Web Services).

MICROSOFT

Owns about 6,600 km of submarine cables globally. The company is also heavily investing in this type of infrastructure, as well as in terrestrial dark fiber capacity to connect data centers globally, to compete on cloud costs, and in support of growing data network needs.

Sources: Burgess (2018); Google Cloud (2018); Mauldin (2019); Zimmer (2018).

Another model for accessing submarine cables is an open access model, which has had success with support from (DB), notably the World Bank. For instance, the ACE submarine cable was built under this model down the West Coast of Africa, acting as the first cable to reach a number of West African countries, including Gambia. In this case, the ISP could purchase access in the cable alongside the government, using an open landing station, and additional capacity on the cable could be purchased by ISP who had not bought a share. The model requires for each ISP to have the appropriate license for international capacity, and works best when there is market competition on national cables or wholesale access to the incumbent's network at cost-based prices.

In the case of inland cross-border networks, the use of terrestrial fiber optic cables is the preferred technology. Satellite or microwave technologies are either too expensive or too limited in terms of capacity. Operators may start from a national network initiative until a certain level of maturity and financial stability is reached, or with a cross-border intention right from the beginning. In the latter case, expansion happens through acquisition of operators in other countries or through license acquisitions. Large cross-border networks can often be built by connecting various national networks with cross-border terrestrial operators using sophisticated financial strategies and tax favorable structures. As with submarine cables, cross-border terrestrial cables can also be built via consortia or via stand-alone, single or multiple stakeholder private investment, and financed by DB. From these, DB bear the high financing risk of the investment and are able to capture broader economic benefits. As an example, when the EASSy cable system was built down the East Coast of Africa, underwritten by a loan from DB (including the World Bank), terrestrial cable was included in the plans to connect landlocked countries.

For these cross-border networks, there is always the challenge to coordinate deployment in both sides of the border in terms of timing and location, so a framework for cooperation should be made with neighbors. Of course, if the same company has a license on both sides of the border, then it is easier to coordinate the border crossing. This is more likely if the markets, particularly for international gateways, have been liberalized so operators can deploy at the border and receive incoming traffic on either side and resell to other companies seeking capacity.

National Networks

National optical fiber networks constitute the backbone for telecommunication services in a country. They are designed to increase broadband coverage for the population of a country. Depending on volume levels and market competition, one or multiple backbone networks can cover both large and small cities. This is a common situation in developed countries where high volumes of traffic justify investment in proprietary backbone networks. In less developed countries, it is normal to find one national backbone present with limited outreach (with rural and low-density populated areas not connected). Box 1.3 presents a compilation of some backbone projects in LAC.

Box 1.3. Largest LAC Backbone Projects

ARGENTINA

Argentina has the longest operating fiber optic backbone network in Latin America. The Red Federal de Fibra Optica (Refefo) constitutes the second stretch of its fiber communications infrastructure, counts with more than 30,000 km of optical fiber, and is aimed at connecting more than 1,200 towns and 20 million people. The project is supported by the country's USF, which allocates one percent of telecommunication operators' revenues to the financing of telecommunication infrastructure initiatives.

BRAZIL

Brazil's national fiber optic backbone network is among the oldest in the Latin American region. At the end of 2016, Brazil's optical fiber structure was approximately 30,000 km long with a capacity up to 1.6 Tbps, with 80 percent running over power transmission lines in Optical Ground Wire (OPGW) cables and pipelines.

MEXICO

Through the Conectividad Digital project, Mexico's government outlined the policy guidelines for the development of projects aimed at expanding the backbone infrastructure of the country. Some of the projects include the wholesale-shared mobile network Red Compartida (see Box 2.2), which is intended to cover 92.2 percent of the population by 2024, the México Conectado initiative, and the development of a national fiber backbone, Red Troncal. The objectives were to deploy dark optical fiber strands along Mexico's utility company's optic network, the Federal Electricity Commission (Comisión Federal de Electricidad, or CFE), covering more than 25,000 km of electric power transmission and distribution towers and access points to related passive infrastructure. Due to the change in Mexico's current administration, the Red Troncal project as originally envisioned has been stopped and a new project (double its size, 50,000 km of optical fiber) aimed at increasing access in underserved areas is being studied.

CHILE

The The Austral Optical Fiber (Fibra Óptica Austal, or FOA) project is expected to build about 4,000 km of optical fiber cable connecting the southernmost parts of the country impacting around 400,000 people.

Sources: Bnamericas (2017); Castañares (2019).

Technologies

Broadband access to national networks can be reached via wired technologies such as optical fiber cable, and also via satellite and microwave technologies. However, satellite technologies present challenges in terms of speed and stability when covering national networks, and microwave is not usually suitable for deployment in high-speed backbone requirements. This chapter is only focused on addressing optical fiber, since it is the best-suited technology for covering national backbone networks nowadays, as discussed in the Introduction. Wireless technologies will be further addressed in Chapter 3 in the context of middle and last mile connectivity.

Although maintenance costs for optical fiber cables is not that high, investment costs are, especially in what it pertains to passive infrastructure due to the engineering expenses associated with planning, routing, digging, and piping activities, as well as with installation and connection processes, in particular in an urban setting. In 2017, the company Deutsche Telekom laid 40,000 km of cable in Germany. Its complete optical fiber network measures 455,000 km (the largest in Europe), and annual investments of Telekom in that country are close to US$5.5 billion (von Wagner, 2018). A way of bringing these costs down is to make use of, or reutilize, existing cable paths, manholes, vacant pipes, and collective ducts, in an effort to reduce the civil engineering works to the minimum.

Business, financial, and investment models

Operators and infrastructure investors need to see a profitable business case (whether in the short or long term) before embarking in backbone projects. Developing countries such as those in LAC represent at first glance a higher risk for backbone investors due to the complexity of their geographies, historical background, rather unstable political environments, and low income/unskilled populations, which are typically hard to reach. Nevertheless, these markets also harness a tremendous opportunity if the appropriate business models and partnerships to increase infrastructure deployment are established.

Business and financial models for national and cross-border networks involve the different layers described above and are dependent on each other, each with different economical and technology features. The development of the right business and investment models, as well as of the financial tools to be used, depends on the roles the actors play. A business model's financial needs can be addressed by the state, private entities, or sharing mechanisms. Management of backbone infrastructure is typically done by the state, private contractors, or private DBO. Some of the financial models available include the following:

- Private financing are bonds, loans, listed equity capital, and corporate social responsibility (CSR) grants. This kind of financing tends to be more independent, customizable to the type of role and risk return/interest of investors project based and associated to faster rollouts. Successful cases of backbone deployment also may involve active and strong private sector participation in the form of multi-sector partnerships (see Box 1.4).

- Public financing relates to state-funding alternatives (equity and debt capital, loans, off take agreements, tax increment financing, and infrastructure bonds) that tend to be more restrictive on return on investment (ROI), due to their association to state-given conditionality. Successful cases include combinations of public and private funding.

- Vendor financing includes terms finance, lease option finance, bank guaranteed loan, and documentary credits. It is not used in isolation but as part of broader financing strategies.

- Public outsourcing model refers to a single contract awarded to a private sector organization covering all aspects of the design and/or construction of the network. The infrastructure is built and operated by the private sector, but the public sector retains ownership and some control (ITU, 2013a). Blended or layered financing is a mechanism to support high-impact transformative projects in sectors that are initially unable to attract commercial finance but have the potential to become commercially viable over time. It includes long-term investors, who remain passive as they are looking for cash flow returns.

Box 1.4. Success Factors in Establishing Multi-Sector Partnerships for Backbone Development

▪ Political and infrastructural environment conducive to the implementation of partnerships.
▪ Early engagement of all relevant stakeholders.
▪ Involvement of high-level champions.
▪ Identification of clear and mutually agreed objectives for the partnership from the beginning.
▪ Consistent monitoring and evaluation of the partnership and its intended outcomes.
▪ Clear and realistic resourcing framework whereby each partner is explicit about the resources that they are willing to make available to the partnership, as well as their expectations of the benefits of being involved.
▪ An ethical framework emphasizing a focus on transparency and the building of trust.
▪ A management office or a partnership broker that will ensure the day-to-day effective management and delivery of the partnership.

Sources: Bnamericas (2017); Castañares (2019).

Choosing the most adequate investment model is not easy. Public authorities can do the following to guide their decisions:

- Make sure the model creates an engine for further investments in infrastructure beyond the immediate project in question.
- Identify what are the benefits in keeping control and ownership of the passive infrastructure.
- Identify available public assets that can be contributed to the project to increase its feasibility and lower its risks.
- Decide whether to keep the ownership of the infrastructure but let an operator define and execute the deployment.
- Identify positive and negative aspects of involving vertically integrated operators, as well as how to best support local bottom-up initiatives.
- Define the level of competition required to facilitate penetration of high-quality and affordable services.
- Assess public institutions' capacity to design their role, taking into account their own competencies and strengths, as well as the project needs.

General Implications for Landlocked Countries and Island States

For landlocked countries such as Paraguay and Bolivia in LAC (see Box 1.5), the benefits of submarine cables are only realized when there is an available and affordable cross-border interconnection and strong national backbones. Landlocked countries that can develop cost effective national backbone networks that connect with regional cross-border networks and submarine cables will take advantage of faster Internet connections with low-end user prices.

Some of the factors landlocked countries need to consider when extending their national backbone to reach cross-border or submarine neighbor networks include the following (Internet Society, 2018):

- Transit infrastructure: This refers to the need to evaluate whether neighboring countries have extended their national backbone network to the border to have an access route to the sea.
- Diplomatic relations with neighboring countries.
- Stability of neighboring countries.
- Regional regulation for interconnection and termination agreements. Typically, non-existent or underdeveloped.

With regard to transit pricing, in many instances landlocked countries might incur higher costs for accessing submarine optical fiber cables. However, this is not always the case as operator groups might leverage their presence in neighboring countries thus internalizing transit prices. Other operators might find the prices not cost-oriented. Also, in most landlocked countries, the distance to the next available submarine cable is relatively close—which is relevant when transit is charged by distance—, and the existence of multilateral government agreements may help in bringing transit costs down.

In terms of technologies, satellite remains a particularly useful option for landlocked countries as it helps provide sovereign connectivity and backup in case of cable disruption. Internet exchange points (IXP) keep locally destined data traffic within the country and help reduce IP transit traffic costs. IXP also improve quality by lowering latency, serve as hubs of technical expertise, and are attractive to foreign and local content providers. Also, IXP keep local Internet sites running in case a country experiences disruption to its international bandwidth.

Landlocked countries should aim at concentrating efforts in expanding their current national Internet infrastructure (e.g., via competition, wholesale, or public–private partnerships—PPP), to all border crossings to enhance their options. In addition, a strong cooperation with multilateral bodies is needed to promote competition in delivering connectivity to inland borders. Regional trade agreements that lower the costs of connecting coasts to inland borders are also very important for these types of countries.

The issue that the landlocked countries face is the snowball effect on IP transit prices. Starting with the cable landing station, international carriers may offer international IP transit at a certain price. That IP transit may be brought into a coastal country by a national operator, who adds an additional price at the landing station, and another to carry it across the country, where it is handed off to the operator in the landlocked country, who may add yet again to the price.

Ideally, the carrier in the landlocked country would be able to pick up traffic at the landing station and bring it into its country. As it would not sell service in the coastal country, it should not need a full operator license. Of course, this assumes that the operators have a cable that connects at the border over which traffic can be carried, which needs to be coordinated between the countries.

One solution that was very successful in landlocked Rwanda was for the World Bank to provide a grant to the government of that country to purchase a bulk amount of international transit coming into Rwanda through its neighboring region. Given the volume and length of the contract, the price was very favorable, and this capacity was made available to ISP in smaller quantities, at the lower rate. This brought down costs significantly,[5] and when the contract ended, new capacity from Liquid Telecom was available at a similar low rate.

[5] According to the UN-OHRLLS's (2017)report, wholesale price of international bandwidth in Rwanda went down from US$10,000 per MBps per month in 2008 to US$125 in 2014,becoming one of the cheapest in Africa.

Box 1.5. Paraguay: Challenges and Opportunities

Together with Bolivia, Paraguay is one of the two landlocked countries in Latin America. Having no access to the sea increases connectivity challenges for this country where there is already a low fixed broadband penetration, an increase in demand, and low international bandwidth per Internet user.

Institutions and Regulatory Framework

In Paraguay, the Ministry of Public Works and Communications establishes all telecommunication policies, and coordinates between the executive power and institutions active in the ICT sector. The state is also responsible for the promotion, control, and regulation of telecommunications through the National Telecommunications Commission (Comisión Nacional de Telecomunicaciones, or CONATEL). It establishes the free and equal right of access to the use and provision of telecommunication services and administers the country's USF. Contributions to the USF resources come from 20 percent of operators' taxes, as well as assignments, donations, and other contributions. The Ministry of Information and Communication Technologies was created in 2018 to replace the National Secretariat of Information, Technology and Communication (Secretaría Nacional de Tecnologías de la Información y Comunicación, or SENATICs); the Ministry is in charge of preparing, promoting, implementing and monitoring the public policies, plans, programs and projects of the ICT sector. The National Telecommunication Plan (Comisión Nacional de Telecomunicaciones 2016-2020) serves as the framework for investment, stimulus, and development efforts that will allow Paraguay to advance towards a more connected, inclusive society.

Connectivity Challenges:

- Better governance of all ongoing initiatives for increasing connectivity.
- More active participation of the private sector.
- Increase focus on services and not only in connectivity.
- Improve territorial balance (making sure that all regions have a more balanced access to broadband networks and services).
- Increase the deployment of fixed broadband networks. Subscription to fixed broadband services continues to be low in Paraguay (4.6 percent in 2018). Access from the fixed broadband network is limited with the dominant technology being cable modem, followed by Asymmetric Digital Subscriber Line (ADSL) and Worldwide Interoperability for Microwave Access (WiMAX); there are few fiber to the x (FTTX) broadband network deployments to provide last mile connections.
- Increase Internet access speeds. The recent launch of fourth generation of broadband cellular network technology (4G) will progressively increase access speed. The average speed of Internet access in the fixed network is relatively low, with most connections below 2 Mbit/s.
- Improve bandwidth and fixed broadband connectivity prices. Prices remain relatively high, compared with the rest of South America.
- Reduce deployment barriers that prevent rapid deployment, especially those imposed by the territories or municipalities when processing permits, licences, and authorizations.

Opportunities:

- Accelerate the deployment and coverage of broadband networks, through the sharing of initiatives.
- Private sector participation. The inclusion of the private sector in government initiatives will improve the execution of strategies and will increase public-private cooperation and private financing of projects.
- Interconnection and infrastructure sharing for accelerating the deployment of broadband infrastructure.
- Policy and Regulation. A revision and update of the Telecommunications law into a more forward-looking legislation, focused on a common vision and strategy for both connectivity and services.

▪ Improvement of International Communications and collaboration especially with neighboring Bolivia. If Paraguay and Bolivia guarantee good connectivity with Atlantic and Pacific Ocean submarine cables through neighboring countries, there is an opportunity for the existing IXP to become an important peering point for all countries in the region.
▪ Unify governance, transparency, and a more efficient management of undergoing initiatives.
▪ Develop and promote ICT use in all sectors of the economy, improving citizens' quality of life, productivity and competitiveness.
▪ Potentiate the use of Telecenters, especially in remote areas.
▪ Potentiate the use of IXP. In Paraguay, an IXP has been created, involving an international company and 14 national companies.
▪ Harmonization of telecommunication policies and regulation to facilitate the development of international connectivity projects. Focus should not only be on access to the traditional services of ICTs (i.e., voice, video, and data), but also on public services (e.g., e-government, e-commerce, e-health, and e-education).
For a landlocked country such as Paraguay, there are several solutions to increase the amount of international capacity available and lower the cost. First, if a new submarine cable lands on neighboring countries and has international support, such as from any DB, it can include a provision for terrestrial fiber connections to Paraguay. This was done for the EASSy cable system down the East Coast of Africa. If no such cable comes to fruition, the model must come from within the country. Noting that there are significant economies of scale for international capacity, the government or a consortium of ISP can purchase capacity in bulk at a volume discount, and then distribute it at the lower price. This was done in Rwanda with the assistance of the World Bank. The capacity can be as IP transit, or dark fiber can be purchased with an IRU and the IP transit can be purchased at the landing station in the neighboring country.

Sources: Conatel (n.d.); ITU (2013b, 2018b); UNOHRLLS (2017); World Economic Forum (2019).

Island states

There are 26 island states in the Caribbean, 13 of which are independent. As it is the case with landlocked countries, small island states (which are typically developing countries with vulnerable and small populations and higher exposure to natural disasters and economic disruptions), face significant challenges in Internet connectivity due to their location, high costs of open sea crossing, and small populations with low years of schooling, all of which lead to higher connectivity costs (Jensen, and Minges, 2017).

Lack of proper ICT infrastructure is only one part of the challenges. Low-income populations and cultural aspects such as language also impact ICT use and its adoption in small island states. Secondary training, skills development, and ICT certification programs are strongly needed as well as entrepreneurship education focused on digital technologies to develop an ecosystem for the creation of ICT related startups.

According to the Internet Society report on small island states entitled Ensuring Sustainable Connectivity in Small Island Developing States (Jensen and Minges, 2017), although second generation wireless telephone technology (2G) is approaching ubiquity, there are still gaps in the availability, costs, and quality of broadband. Anglophone Caribbean nations tend to have higher levels of fixed broadband penetration due primarily to higher incomes. Mobile broadband has spread significantly compensating for the lack of fixed broadband access. However, unlike 2G, the coverage of third generation of wireless telephone technology (3G) is not as widespread. This expansion of mobile broadband has been mainly due to market liberalization and increased competition over the past decade. This report from the Internet Society also states that most small island states in the world are now connected to at least one submarine cable, and many have deployed national optical fiber backbone networks. Despite these successes, challenges (especially in high-speed Internet access) remain.

To address their connectivity challenges, small island states might take advantage of nearby submarine cables planned for other destinations as long as there are policies and financing mechanisms established to help these countries raise the necessary funds. In addition to submarine cable projects currently being deployed, other technical opportunities for these types of nations include IXP, satellite systems, wi-fi, dynamic spectrum sharing, and software defined radio. Sub-regional projects involving intra island cooperation could also work by generating economies of scale that justify return on investment. Taking advantage of regional hubs is another alternative, as long as regional operators aggregate their traffic to get more discounts on larger volumes of data. Finally, minimizing barriers to entry by providing incentives, reducing license fees, land costs for landing stations, and lowering cable-landing fees can also be an interesting mechanism for these nations to address their connectivity challenges[6].

[6] According to the Internet Society report (Jensen and Minges, 2017), members of the Eastern Caribbean Telecommunications Authority agreed that cable-landing fees should not be more than an initial US$50,000, plus US$55,000 per year thereafter.

2. Middle and Last Mile Internet Connectivity

Strategies and Business Models for Improving Broadband Connectivity in Latin America and the Caribbean

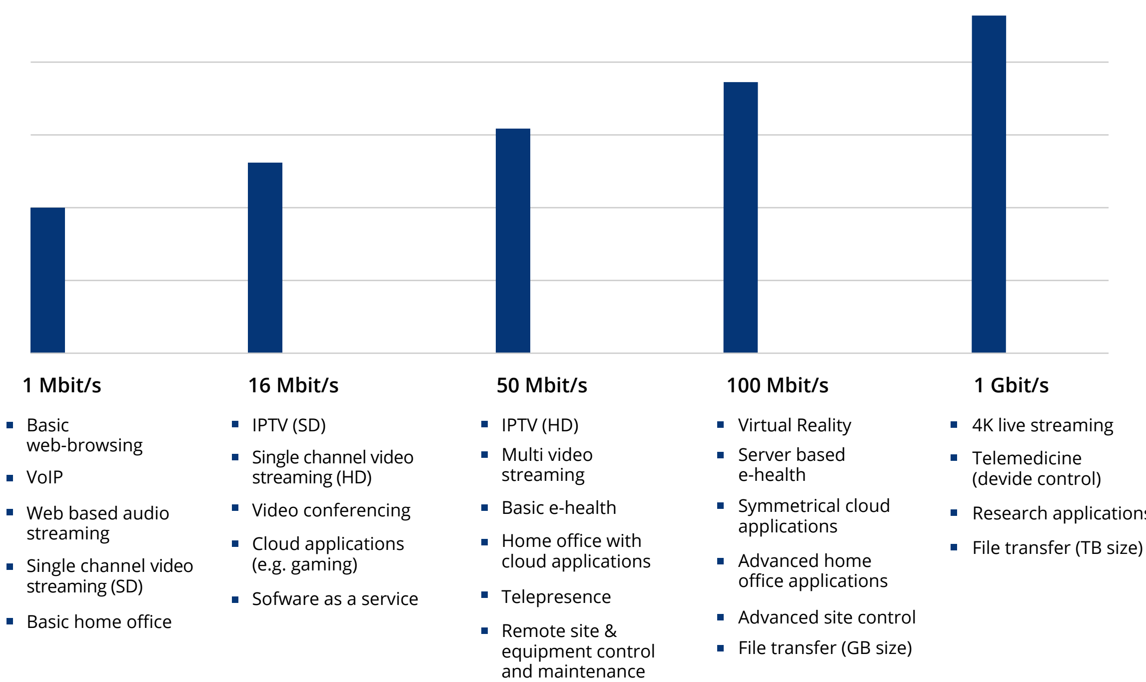
Guidelines for the Planning, Investment, and Rollout of Broadband Networks

2. Middle and Last Mile Internet Connectivity

Middle mile is the industry term used for describing the network infrastructure that connects last mile (or local) networks to other network service providers, telecommunication carriers, and the Internet. In the middle mile, Internet is brought to a point in a community for further distribution. T the typical distances for middle mile coverage go from 10 to 100 km. In contrast, last mile is the term used to describe the infrastructure carrying signals from the middle mile along the relatively short distance (i.e., last mile) to and from the home or business. Last mile distances range between one and five km.

The comparatively short distances of last mile networks help prevent major signal attenuation. Hence, last mile networks are able to satisfy a wide variety of capacity needs, ranging from Mbit/s to Gbit/s, depending on the online services running on top of it. In order to provide advanced online services, notably video, to end users, government buildings, schools, and/or businesses, the network speed must be at a significant level, as shown in Figure 2.1.

Figure 2.1. Network Capacity Needs



Source: Bouwfonds (2017).

Technologies

Middle and last mile technologies can be grouped into wired and wireless solutions. Wired technologies include optical fiber and cable, and wireless technologies span from mobile broadband to microwave to satellite.

Copper and fiber are the most frequently-used technologies for national deployments. Copper wires, also called “legacy telephone unshielded copper twisted pair”, provide broadband connections by using xDSL technologies or very-high speed digital subscriber line (VDSL). Copper requires relatively low investment for passive infrastructure but higher investments in active equipment. With copper, download speeds depend on the length of the copper line and the costs of upgrading old national networks are typically higher than replacing them with fiber. Copper still exists in legacy networks but would not be deployed in new broadband networks.

Optical fiber technology has a transmission capacity that is far superior to any existing cable-based technology, as well as significant potential for future upgrades. Optical fiber can therefore offer an extremely high level of service to end users and become the building block for services such as e-health and telemedicine, the Internet of things (IoT), residential buildings automation, e-learning, e-jobs, and electronic transmission of power consumption. Given that the cost of civil works is the same as deploying copper and coaxial networks, and that higher speeds are available over optical fiber, this would be the technology of choice for new deployments.

Mobile technologies are becoming more dominant for broadband delivery as they are in principle fast and less costly to deploy. Wi-Fi is gaining popularity due to its ease of implementation and low cost. Microwave and satellite are also popular for middle mile but not as fast and efficient as fiber, and in the case of satellite, costs and vulnerability due to exposure to environmental conditions represent an additional point of consideration. Moreover, in comparison to fiber, mobile technologies also present an issue as they rely heavily on spectrum availability and the service levels are less consistent than with fiber (see Annex 2).

Innovations in Access Networks

This section presents a general overview of some innovative tools and approaches to address gaps in last mile connectivity. Drones and balloons are examples of initiatives to expand coverage in hard-to-reach areas. TVWS is a low-cost alternative to make spectrum available for everyone and to bring connectivity to underserved rural and remote populations. Much has been said and discussed about the true impact of these tools and approaches, as they are still at an early stage and have many unsolved challenges to guarantee sustained high-quality performance. Nevertheless, they deserve attention and close monitoring, as their technological evolution might represent a complementary way to solve connectivity problems.

Drones

Unmanned aerial vehicles (UAV) or drones have their origins in the military industry. Although they have existed for a long time, it is in the last decade that they have become popular, leading to their use in other sectors. In the telecommunications industry, drones are utilized to solve issues related to infrastructure and coverage, as well as to bring connectivity to white spots in remote and hardly accessible areas. In a global report on the commercial applications of drone technology, PwC (2016) estimates the addressable market of drone-powered solutions in the telecommunications industry at US$6.3 billion.

Drones have the capacity to fly at high altitudes and cover large areas (from 3,000 to 5,000 km^2) using power generated by solar panels and light onboard equipment. Drones are often categorized as short-term solutions for last mile connectivity, as they are designed to provide fast-to-deploy coverage in a particular area for temporary periods (from a few hours to a few months). For example, although tethered drones are designed to fly for approximately three days, they can potentially be flown for an indefinite amount of time. Drones are usually equipped with 4G, Long-Term Evolution (LTE) antennae, or with Wi-Fi. Low-flying drones are reliant on substantial ground infrastructure for connectivity, so they are less adequate for providing coverage in areas where there is already a lack of basic infrastructure. Some of the obstacles this type of solution presents for last mile coverage includes recharging, speed issues in data transmission, and fly time. Drone technology for last mile access is still evolving and its commercial viability still needs to be tested.

One example of drone solutions was Facebook's Aquila project. It used solar-powered drones and wireless Internet relays with the objective of remaining 90 days in the air covering a radius of 50 km.

In 2018, Facebook announced that it was no longer pursuing its plans of building its own high-flying drones for delivering Internet. Instead, Facebook said it would focus on working with partners on high altitude delivery systems and on policy matters for securing spectrum and rules for the operation of such systems (Statt, 2018).

Balloons

High-altitude platforms or balloons are also being used to provide Internet access and increase connectivity in rural areas. In partnership with satellites, balloons have also shown promising results in providing connectivity after natural disasters (SES, 2017). A network of balloons floats in the stratosphere and acts as a wireless station that provides Internet service to remote regions using 3G/4G and Wi-Fi in a cost-effective manner. Project Loon by Alphabet was the best-known balloon project under development, until it ended in early 2021. It flew at an altitude of 20 km above the Earth's surface and provided a wireless mobile network station in the sky powered with up to 3G speeds.

Balloons are designed to go where they are needed by rising or descending into a layer of wind blowing in the desired direction of ravel (Fung, 2018). They are also launched to provide coverage in a cluster over a certain area, with each balloon being able to cover an area of over 5,000 km^2. In 2018, Project Loon achieved two important milestones: maintaining an Internet connection between seven balloons across a span of nearly 1,000 km, and successfully sending data over 600 km between two balloons. If successful, Project Loon could deliver several billion dollars in annual revenues. Balloon technology is still under experimentation and the business model for commercialization has not been fully defined. There is a significant upfront capital expenditure required, which might imply that only a handful of operators are able to provide the service.

Television white space (TVWS)

TVWS is the spectrum from now-unused analogue television channels. It can be used to provide broadband Internet access without interference, and it is a low-cost alternative technology that can bring connectivity to underserved rural and remote areas. Ultra-high frequency (UHF) band can cover long distances and provide speeds of 15 Mbps with standard regular equipment, and up to 150 Mbps with new equipment. The main requisites are that the channels considered are not in use at the moment of allocation, and that the TVWS does not cause interference with other signals. In the last decade, TVWS gained some momentum due to standardization by the Institute of Electrical and Electronics Engineers (IEEE). Although there are no large-scale deployments so far, there are currently 11 countries in the world (including the United States, United Kingdom, Singapore, Mozambique, South Africa, Colombia, and South Korea) which have adopted TVWS regulations.[7]

[7] Interview with Martha Suárez, President of the Dynamic Spectrum Alliance, August, 2019.

TVWS has many distinct advantages. Its frequency signals (ranging from 450 to 800 MHz) can travel over long distances (typically 15 km) at low power, and its non-line of sight (NLOS) characteristics can penetrate walls and buildings, which makes it ideal for bridging the connectivity access gap in rural areas. Another advantage is that TVWS is generally less expensive to set up than conventional mobile or optical fiber networks and can potentially be deployed without the need of high-level expertise and technical resources.

One of the disadvantages of TVWS is that the available bandwidth is restricted due to the low frequencies used. As TVWS is indeed the result of badly allocated spectrum, regulators might consider that the costs and benefits of narrowing these buffer channels and making more spectrum available could offer better solutions to more end users through more traditional allocation mechanisms. Spectrum management is another big challenge for TVWS to be successful. As unlicensed spectrum does not generate license revenue and reduces the regulatory management and administration burden, it may imply a significant change from past approaches in which regulatory authorities closely controlled spectrum use and imposed license fees to support the administrative role. As license fees have been used to generate revenue or cross-subsidize other government activities, the use of unlicensed spectrum may impact such structures and challenge the status quo (World Bank, 2019).

Despite the challenges, there are many global examples of successful implementation of TVWS. The 4Afrika initiative launched by Microsoft in 2013 is an example of an effective use of TVWS for increasing coverage in remote rural areas. As part of this initiative, Microsoft has launched 15 TVWS connectivity pilots across many countries in Africa, including Kenya, Namibia, Ghana, Tanzania, and South Africa (Microsoft, 2012).[8]

Before turning to the next section, it is worth mentioning that any effort to bring connectivity to the last mile is worth exploring. All the above-mentioned solutions might not become broadband substitutes but complementary alternatives, which are worth following. It is necessary to continue testing them and see whether economies of scale develop, allowing some of these technologies to reduce prices so they also become profitable in the last mile.[9]

[8] Interview with Frank McCosker, Director of the Global Good Networks, August, 2019.

[9] Interview with Ricardo Martínez Garza, former Advisor to the Undersecretary of Communications, Secretary of Communications and Transport, Government of México, October, 2019.

Business, Financial, and Investment Models

To increase the possibilities of last mile connectivity, it is important to share the costs of network deployment. Much of this is done in the middle mile network, which serves the fixed last mile networks and the mobile towers. To the extent possible, "dig once" policies and passive infrastructure sharing is important for lowering costs. Box 2.1 provides an explanation of the different modes that these policies involve.

Box 2.1. "Dig Once" Policy

The "dig once" policy is a popular and efficient way municipalities can employ with underground utility projects to make way for the inclusion of optical fiber cable in construction. It encourages the installation of additional conduits for optical fiber cables and it eliminates the need to dig up recently created roads to expand broadband infrastructure, which in turn could significantly reduce the costs of providing Internet access to underserved communities.

There are several types of "dig once" policies, including the following:

- **Joint trench agreement:** It aims to improve coordination with telecommunication providers so infrastructure is installed at the same time in the same trench or conduit. In most cases, infrastructure installation costs are shared.
- **One touch agreement:** The conduit is installed during any relevant government-funded construction project. Moratoriums on street excavation are placed to preserve new roadway construction and encourage proactive installation of conduits and dark fiber.
- **Shared leasing:** Refers to an agreement where multiple ISP share the cost of leasing infrastructure. It was designed to reduce obstacles to shared access of existing poles, ducts, and conduits.
- **Utilities partnership:** When fiber can be installed at the same time than sewer and water projects to increase cost savings.

Opponents to the policy argue that it creates more operational overhead, which in turn presents problems to local incumbents who will have to allow competitors to gain access to their fiber connections, thus increasing the risk of losing market share. Its supporters, on the other hand, claim that the costs of underground fiber deployment in conjunction with road construction projects is about a quarter of the regular cost per mile of pole mounted for fiber. Goldman Sachs has estimated that it could cost about US $140 billion to build high-speed service out to the entire United States. But if "dig once" policies were implemented nationally, it could provide up to US$126 billion in savings.

Sources: Cooper (2019); OTELCO (2017).

Mobile operators can consider a variety of approaches in the last mile. In addition to sharing backhaul to the towers, operators can share the towers themselves. This is often done with an independent tower company that can specialize in deploying networks, installing MNO equipment, and maintaining the towers.

At the spectrum level, it is important again to lower costs, particularly to enable upgrades of networks from voice to broadband and from 3G broadband to 4G and 5G. Each successive generation enables more efficient use of spectrum and greater bandwidth for end users. This can be done by allowing operators flexibility in their usage of current spectrum allocations, rather than having to purchase new allocations. Otherwise, explicit spectrum repurposing is also helpful to enable upgrades to new technologies.

In addition, it is important to make available an adequate amount of spectrum, and in good spectrum bands. For instance, lower frequency spectrum (e.g., 700 or 800 MHz) has much better propagation properties than higher bands, thus fewer towers are needed, particularly in rural areas.

Box 2.2. Red Compartida

In 2013-2014, the Mexican government started transforming its telecommunications and broadcasting sectors by introducing groundbreaking reforms aimed at eliminating monopolistic practices, increasing competition, suppressing long distance phone charges, and making it easier for customers to switch phone companies and broaden access to free-to-air television stations. Under these new laws, the Federal Institute of Telecommunications of Mexico (Instituto Federal de Telecomunicaciones, or IFT), was created as an autonomous state agency to regulate telecommunications and broadcasting services according to the Constitution and Mexican law. The 2013-2014 reform also required the establishment of a wholesale-only wireless network or "carrier of carriers" that would sell mobile network capacity covering 92.2 percent of the population. As a result, in November 2016, Red Compartida was born. Consequently, in January 2017 the contract was awarded to Altán Redes, a consortium of private investors from Mexico and the United States, as well as participation from the International Financing Corporation (IFC), Axtel, and Megacable (Mexican operators). Red Compartida is a US$7 billion project that will sell mobile network capacity to all existing operators as well as new entrants, but not directly to end users. The goal the Mexican government wants to achieve through Red Compartida is to increase mobile population coverage, facilitate market entry, enhance competition, and increase the choice for consumers. Red Compartida uses cutting edge 4.5G technology from conception to deployment in all its footprint and it is ready for 5G. The network concession is for a term of 20 years with an option to extend for another 20 years with the following main objectives in mind:

- To optimize the usage of assigned spectrum (700 MHz band).
- To reduce costs and promote market competition.
- To increase coverage in regions without telecommunication services.
- To raise the quality to international standard services.

"There are 192,000 localidades (towns) in Mexico and 66 percent of the country population is concentrated in only 930 of them. In a country such as ours with 130 million people and a very complicated geography, creative schemes must be developed to promote network coverage so that within a reasonable timeframe supplying the demand in rural areas becomes a sustainable business. The objective of Red Compartida is to reduce the cost of deployment by having a single infrastructure that can be used by all operators. Red Compartida is the world's first exclusively wholesale network with no services provision to the end user". Ricardo Martínez Garza.

Under the terms of the PPP, the Mexican government is bound to provide the radio spectrum (90 MHz of the 700 MHz band), the use of the 25,000 km of backbone fiber network developed by the CFE, and more than 18,000 government sites nationwide for network deployment.

Altán Redes aims to offer incumbent MNO additional coverage or capacity as well as service to other operators (MVNO and fixed operators). The concession requires that access to the network is offered under non-discriminatory terms, meaning that all the clients of the Red Compartida have the same prices and conditions and that any modifications are communicated to all equally. Altán Redes has developed tailored solutions for better integration with clients, which include wholesale packages for home broadband (HBB) services and wholesale voice and data plans for mobile services for MVNO and fixed network operators (FNO) turned-MVNO (allowing these to offer quadruple play).

The project also requires commitment to certain milestones and metrics on quality of service and a minimal coverage target of 85 percent of the population by 2022. In the offer presented, Altán Redes committed to 92 percent of population coverage by 2024.

Coverage milestones and time horizon

- **First milestone:** 30 percent of population coverage by March 31st, 2018.
- **Second milestone:** 50 percent of population coverage by January 2020.
- **Third milestone:** 75 percent of population coverage by January 2021.
- **Fourth milestone:** 85 percent of population coverage by January 2022.
- **Fifth milestone:** 88.6 percent of population coverage by January 2023.
- **Sixth milestone:** at least 92.2 percent of population coverage by January 2024.

In addition to each milestone of coverage, a minimum quota of rural population coverage was also established. This way, the percentage of coverage in rural areas will only be credited if the minimum quotas in rural areas are met. For every 1 percent of the urban population to be credited, Altán Redes must cover at least 0.15 percent of the rural population in the first two milestones. As for the third milestone, all urban areas should have been covered and all the remaining areas would be rural.

The bidding winning criteria was the issue of coverage, provided all contestants met on a pass/fail basis a very stringent set of conditions, leaving aside the issue of digital inclusion. This was due to an interesting phenomenon that has been seen in Mexico in recent years.

> *"Even though digital inclusion is needed in various sectors of the population, the new generations are quite digitized and electronic devices such as cell phones and tablets are being sent to rural areas by family members living in urban areas or outside the country. Access to the device is not an insurmountable barrier in Mexico. The need to remain connected pushes communities to learn the use of these devices and to go down to the municipalities, where there is greater coverage and Internet access sites to be able to connect".* Ricardo Martínez Garza.

Current Status of Red Compartida

Although it is still too early to call it a success and to draw lessons from this one-of-a-kind partnership, Red Compartida seems to be in track to achieve its objectives and key milestones. In March 22, 2018, Red Compartida was slightly ahead of target, having covered 32.2 percent of the population. Investment for the first milestone amounts to US$420 million[4], with 2,275 towers (out of the 12,000 towers envisioned for the entire project) being used and 11 large cities (including parts of Mexico City, Monterrey, Guadalajara, Toluca, Queretaro, Puebla, Morelia, Colima, Tepic, Aguascalientes, and Celaya) having been fully covered. According to Altán Redes, the coverage achieved during the first milestone of the Red Compartida impacts 36 million Mexicans, of which 15.5 percent live in towns with fewer than 10,000 inhabitants2. It is estimated that by the end of 2019, the 50 percent of the population milestone will be achieved, that is, about 60 million people (more than 11.5 million in populations of less than 10,000 inhabitants).

Since March 2018, when the commercial activities started, Altán has already signed with over 35 clients. The strong interest of companies entering the telecom market is proven by the 156 percent increase of new permits granted since 2016. Some wholesale partners have already started to use Red Compartida and to provide services to end users. In January 2019, Megacable launched its MVNO under the "Mega 4.5G" brand with services available only to its own subscribers. In May 2019, Airbus launched MXLINK, its secure mobile virtual network operator (SMVNO) for Mexican public safety and defense authorities. MXLINK offers multi-operator coverage, interoperability with the National Radio communication Tetrapol network and end-to-end voice and data security. MXLINK uses Red Compartida for providing reliable, secure and high-quality service to police officers, firefighters and members of national defense. It is expected that other wholesale partners will also start joining the network and providing services soon.

Despite the important accomplishments thus far, some challenges have also started to emerge. Although regulation of Mexican telecommunications takes place at the federal level, those who grant infrastructure construction permits in the municipalities are the localidades (towns). The deployment of infrastructure then becomes complicated since the processes and quotas are not necessarily homologated, which sometimes generates duplication of efforts and different paperwork for acquiring the same permit or license. This is a phenomenon that is repeated in many countries of Latin America, which must be followed up and addressed as it directly impacts the success or failure of any project that seeks to increase coverage and broadband access.

The 2013-2014 telecommunications and broadcasting reforms in Mexico have started to pay off. It is estimated that the competitive environment created by the reform has generated US$6,900 million in savings to the Mexican population between the periods 2013-2017. The country's predominant mobile operator, which controlled 70 percent of the market has started to see a dent in their market share as more competitors start offering services. According to IDB data, current split for mobile telephony in the country gives Telcel (América Móvil) 65 percent, Movistar 23 percent, and AT&T Mexico 11 percent of the market. As Ricardo Martinez Garza stated, "The creation of IFT has brought greater supervision and the entry of Red Compartida has begun to balance or remove and reverse the trend of preponderance" If successful, the Red Compartida network will be the first fully wholesale mobile network deployed in the world for middle and last mile with the potential to catapult Mexico to the third place in worldwide connectivity.

Sources: Altán Redes (n.d., 2019); Government of Mexico (2014); Juárez Escalona (2018); Leins (2019); Nally (2019); TeleGeography (2016); World Bank (2019).
Note: Additional information was obtained from interviews with

Ricardo Martínez Garza, Former Advisor to the Undersecretary of Communications, Secretary of Communications and Transport, Government of México. Currently, International ICT Consultant; and Juan Carlos Hernández Wocker. General Coordinator International Affairs. Federal Institute of Telecommunications. Government of México.

Likewise, spectrum auctions should not prioritize the maximization of government revenues at the expense of operator deployments. One model is to include coverage requirements in spectrum licenses (see Box 2.2 and Box 2.3). The MNO will bid less for the auction to be able to finance the deployments as per the coverage requirements, but they may be able to place their savings to more efficient infrastructure deployments to narrow the digital divide. However, this would require that governments or national regulatory agencies increase their enforcement capacity to ensure that obligations are fulfilled and apply effective penalties in case they are not. On the other hand, where mobile operators still do not deploy, other operators like community networks could have access to the spectrum in those specified geographic areas (1 World Connected, 2020). The following are some of the community deployment models that may be found for such purposes (see also Box 2.3):

- Private or public DBO model: This is a model where the public authority (or a private sector company) builds, runs, and controls a broadband network in the municipality, county, or region. A newly established company or a dedicated division within an existing utility deploys the network directly or through standard procurement to the market. The public authority or the private sector company keeps ownership of the network. An example of a public DBO model is rural Finland (EC, 2020c).

- Privately-run municipal network model: The public authority procures the building and operation of a broadband network in the municipality, county, or region from a private actor (public outsourcing or concession model). The public authority keeps ownership of the passive infrastructure, the private actor builds an open, operator-neutral network over which service providers can deliver services to users, but the operation contract with the external firm is typically in the form of an IRU. The private firm building and operating the network is in most cases barred from delivering its own retail services. The contracted firm commits the investment and takes all the revenues but also the business risks for the whole contract period. At the end of the contract, the network infrastructure remains with the public authority, which may then decide to renew the contract, to sign a contract with another company or even change its involvement altogether and adopt a public-run municipal network model. An expression of such model can be found in the Piedmont region, in Italy (EC, 2020c).

- Community broadband model: Broadband investment is carried out as a private initiative by local residents (bottom-up approach). The public authority can support co-financing and ROW granting, regulation, and coordination with other infrastructure deployments and access to public infrastructure and points of presence (backhaul connections). Public authorities can also help establish fair conditions for all operators seeking access to the infrastructure. This model has been applied in many places around the world including the Netherlands, some parts of the United Kingdom, and Mexico (i.e., the Rhizomatica project).

- Operator subsidy model: In this model, the public authority is not directly involved in the broadband deployment projects of the region, but subsidizes one market actor to upgrade its own infrastructure. Incumbent telecommunications operators and large alternative providers usually own the passive infrastructure, active equipment, and offer services to end users in a vertically integrated model. The public authority funds the gap between what is commercially viable and the coverage that the public authority aims to achieve. Funding is offered as a grant to one or more private operators. This model offers simple contractual agreements, a rapid deployment, and the offset of risks to the operator. Public authorities will not receive financial rewards but will have to face higher funding requests for each development phase. Germany is a clear example where this model has taken place.

- Community funding: Community funding mechanisms such as asset transfer (ROW) community bonds, subscriber equity, and finance are suitable for small/last mile initiatives.

- DB: Typically used by governments in combination with private sector financing mechanisms. A DB is concerned with investment project financing, trust funds and grants, development policy financing, loans and equity capital to private sector, syndications, and blending concessional finance.

- USF: System of telecommunication subsidies and fees designed to fund projects that extend universal access to telecommunication services. They are typically used to target remote or underserved areas with hard to reach, under-skilled and vulnerable populations. USF are financed by contributions from telecommunication providers (including wired and wireless companies) and interconnected VoIP providers (including cable companies). USF have come to criticism lately, as they have not been effective enough in achieving the universal access they promised. Studies have shown that more than half of the sums collected were never utilized and over a third of the funds were not able to distribute any of the levies collected. In Brazil, where payments to the USF have amounted to 1 percent of operator revenues since 2000, the fund is now US$6 billion and largely unused due to broadband technology restrictions set by the current regulatory framework, which was conceived for funding fixed telephony projects. In the Philippines, the fund was closed, and the use of the funds is currently unknown. In India, the usage rate is 50 percent, suggesting that the fee set for the contribution may be too high. Box 2.4 provides more detail into the operations of this model. Alternatives and complements to USF include promoting private network-sharing and multi-sector/public-private partnerships.

Box 2.3. Community Networks: Alternative Solutions for the Last Mile

Community networks are another example of unlicensed spectrum use for last mile coverage. These associations are small networks built and operated by community members or entrepreneurs seeking to bring connectivity to villages or towns not yet covered by commercial mobile networks. They are collectively owned and managed by the community for non-profit and community purposes. Community networks typically use Wi-Fi technology or simple 2G mobile networks, which are built to meet the needs of a specific community. The establishment and expansion of community networks depends on many variables, such as the existence of efficient and sustainable local organizations, the availability of technological capabilities, the number of available resources, and the existence of friendly environmental and regulatory conditions.

Although community networks have been in existence for quite a while, their regulation is scarce, as government efforts typically tend to focus on addressing the behavior of the big players in the telecommunications markets.

In relation to their business model, community networks can be classified into three groups: (i) networks for the self-provision of services, (ii) networks offering services to third parties, and (iii) mixed systems. Depending on their nature, community networks may find themselves complying with regulations deriving from the characteristics of the services they provide. Policy makers seeking to foster community networks may need to review current policy and legal frameworks to identify obstacles to the development of such networks.

In recent years, the number of community networks in LAC has grown significantly. They aim to provide an alternative solution for connectivity to the almost 250 million Latin Americans who are still unable to access the Internet (20 percent of which live in rural and isolated areas). Community networks in the region have been established as an option to escape the failures of market logic or the inefficiency of state subsidies to address the connectivity problem.

For example, in Colombia the community networks movement has been active for more than 10 years. Bogotá Mesh, Red Fusa Libre, and Network Bogotá are just some examples of community-led efforts where money has been raised to buy equipment for establishing Wi-Fi zones in areas with very basic infrastructure and low-income populations. Some of the services offered through these initiatives include voice over Internet protocol (VoIP) telephony, micro blogging platforms, and development of educational content for rural schools. One of the challenges that Colombia faces is that there is no regulation allowing the use of spectrum for mobile communications without a public auction. With the support of the National Spectrum Agency in Colombia (Agencia Nacional del Espectro, or ANE), this problem is being addressed in the community network of Buenos Aires, Cauca, where a portion of the spectrum in the 900 MHz band was released in order to develop policy recommendations aimed at the deployment of rural community-based telecommunication networks. The pilot seeks to evaluate the feasibility of operating community-based mobile phone networks in areas where there is no coverage by commercial operators. The pilot also seeks to interconnect these networks to the closest municipality with a fiber optic link to the Internet.

Despite all the concentrated efforts, there are still difficulties in accessing the use of the spectrum needed for these networks to succeed. This leads to frustration in the communities and withdrawal from supporters, which in turn undermines the legitimacy of the entire initiative. In Colombia and in many LAC countries there is a pressing need for regulations that facilitate the deployment of community networks in disconnected rural areas. Organizations such as the Internet Society, the Latin America and the Caribbean Network Information Center (LACNIC), the Inter-American Telecommunications Commission (Comisión Interamericana de Telecomunicaciones, or CITEL), and the Organization for American States (OAS), are doing important work to promote and support community networks but more efforts need to be done at the national level.

Sources: Association for Progressive Communications (2019); Baca et al. (2018).
Note: Additional information was obtained from an interview with Jane Coffin, Senior Vice President, Internet Growth. Internet Society, September, 2019.

Box 2.4. Universal Service Funds

At the recent Sixth Annual Conference on Spectrum Management for LAC experts agreed that USF have been ineffectively used in the past 25 years. It was also said that some of the challenges for USF success are: ▪ Their design and implementation, since USF need to be technically sound but also flexible to allow for multiple models.
▪ Dependency on bidding processes. In the case of LAC countries, bidding processes tend to have a negative impact on the effectiveness of USF, since they can be long and complicated. By the time the contract is awarded, projects need to start with a demand input that does no longer match market conditions.
▪ Lack of transparency without set targets, especially for resource allocation, operator's focus, and collaboration.
▪ Lack of coordination between the private sector, interest groups, and governments.
▪ Reluctance to involve other entities. The ITU recommends integrating FSU with each country's digital agenda, which means the involvement of new actors such as community networks, small and medium-sized enterprises (SME), or co-operatives in the form of partnerships.
▪ Poor regulatory framework, which do not state clearly what the USF are for.
▪ Poor or inefficient administration.
▪ Lack of technological neutrality.
There are, in any case, some success stories worth noting: ▪ **Connect America Fund:** It assigned US$488 million to connect rural areas of the United States and give access to Internet to 700,000 people over 10 years.
▪ **Colombia:** The USF has been structured to be financially autonomous and projects are awarded in a highly transparent manner via public bidding processes.
▪ **Peru:** To keep private investment, the USF in Peru, known as Fitel, uses smart subsidies. It sets out the criteria for a build out in terms of coverage, prices, and quality of service, and then holds a 'reverse auction' in which the company asking for the lowest subsidy wins the project to meet the requirements of the tender.

Sources: Connected Society (2016); Carreño (2019).

There are also some success stories such as the one from the US Federal Communications Commission on the broadcast incentive option. This is detailed in the Box 2.5.

Box 2.5. US Broadcast Incentive Option: Reverse and Forward Auctions

The US broadcast incentive option comprises two separate but interdependent auctions: a reverse auction, which determines the price at which broadcasters will voluntarily relinquish their spectrum usage rights; and a forward auction, which will determine the price companies are willing to pay for flexible use wireless licenses. These auctions are joined by a "repacking" process in which channels are organized and assigned to the remaining broadcast television stations to create contiguous blocks of cleared spectrum suitable for flexible use. Each of the components must work together to be successful. The reverse auction requires information about how much bidders are willing to pay for spectrum licenses in the forward auction. The forward auction requires information regarding what spectrum rights were tendered in the reverse auction, and at what price. Thus, each one depends on efficiently repacking the remaining broadcasters.

Both types of auction will then be integrated into a series of stages (also consisting of reverse and forward auctions). Prior to the first stage, the initial spectrum-clearing target will be determined. Broadcasters will indicate through the pre-auction application process their willingness to relinquish spectrum usage rights at the opening prices. Based on broadcasters' collective willingness, the initial spectrum-clearing target will be set at the highest level possible. The auction system will establish a band of wireless spectrum that is generally uniform in size across all markets. Then the reverse auction bidding process will be run to determine the total amount of incentive payments to broadcasters required to clear that amount of spectrum. The forward auction bidding process will follow the reverse auction bidding process.

If the "final stage rule" is satisfied, the forward auction bidding will continue until there is no excess demand, and then the incentive auction will close. If the final stage rule is not satisfied, additional stages will be run, with progressively lower spectrum targets in the reverse auction and less spectrum available in the forward auction. In the final stage rule, a series of conditions must be met to close the auction at the current clearing target. If the rule is not satisfied, a new phase will be run at the next lowest clearing target.

Source: FCC (2017).

Conclusions

Middle and last mile networks are built to complement the international and national networks discussed in Chapter 1. These networks have the additional feature of providing retail service to end users. Thus, to the extent that competition can be introduced in the networks, there will be more choices available to end users. This can be done through sharing infrastructure throughout the network (particularly with passive infrastructure) to lower costs, as well as through wholesale access whenever feasible.

However, to promote last mile networks for end users, it is also important to focus on the demand. This includes ensuring affordability of access, which will be assisted by ensuring competition and infrastructure sharing. It also requires ensuring access to affordable devices and relevant content and services, including government services, and building capacity to teach the skills needed to go online to access content and services. Any government support for broadband networks aiming for a holistic approach should ensure that these issues have been addressed in order to increase uptake and usage, which in turn will help to promote further investment.

3. Case Studies

Strategies and Business Models for Improving Broadband Connectivity in Latin America and the Caribbean

Guidelines for the Planning, Investment, and Rollout of Broadband Networks

3. Case Studies

Throughout this chapter, two groups of case studies will be presented in detail. These are the global case studies of Korea, Spain, and Estonia, and the regional cases of Ecuador and Chile. The three global case studies provide a potential milestone for regional countries, while the two regional countries are representative of the current status of many of their peers. Hence, it enables a valuable comparison between the regional baseline and a potential milestone towards which continue evolving.

Global Case Study: Korea

Table 3.1. Country profile: Korea

COUNTRY FACTS	ICT FACTS
Total land area: 100,300 km^2, of which 78,378 km^2 are rural areas	**Mobile cellular subscriptions per 100 people:** 129.7
Population: 51,640,000, of which 80 percent live in urban areas	**Mobile broadband subscriptions per 100 people:** 113.6
Population density: 529.7 per km^2. One of the world's most densely populated countries, with more than 50 percent of households living in apartments	**Fixed broadband Internet subscriptions per 100 people:** 41.6
GDP: US$1,619.42 billion	**Fiber Internet subscriptions per 100 people:** 31.9
GDP per Capita: US$31,350	**Individuals using the Internet (percentage of population):** 95.9 percent
Rank in Global Competitiveness Index: 13 of 141 economies	**Internet affordability:** fiber Internet 1Gbps at US$26–32 per month
School enrollment, primary (gross percentage): 98.1 percent	**Internet speed:** 83.90 Mbps mobile download (number second in the world); 124.39 Mbps fixed broadband download
School enrollment, secondary (gross percentage): 100 percent	**Rank in the ITU ICT Development Index:** 2 (out of 176 economies)
School enrollment, tertiary (gross percentage): 95.3 percent	**Overall rank in The Economist Inclusive Internet Index:** 6 out of 100 countries

Sources: EC (2020c); ITU 2017); Schwab, and WEF (2019); Speedtest (2020); The Economist Intelligence Unit (2020) Trading Economics (2020f), World Bank (n.d.d).

Korea is one of the best examples of a country rising from being at the bottom level of ICT access to one being at the forefront in the world. In the 1960s, Korea had a telephone penetration rate of 0.36 per 100 inhabitants and its Internet penetration rate in the 1990s was only 20 percent (equivalent to 9.43 million users) (ITU, 2013c). Twenty-five years later, Korea is one of the countries with the highest Internet penetration in the world (95.9 percent), one with the fastest Internet speeds (25 Mbps), and in April 2019, Korea became the first country in the world in rolling out 5G. Its Internet usability also ranks among the best in the world: Koreans are one of the world's most technologically savvy populations enjoying ubiquitous connectivity, which allows them to go online and spend an average of 14.3 hours a week on the Internet. Significant steps towards digitalizing its economy have also been made. Digital payments are accepted almost everywhere (ITU News, 2018) and e-commerce is a key component of the overall consumer market. In 2018, domestic online purchases reached US$100.8 billion, making the domestic e-commerce sector account for about 30.8 percent of Korea's retail industry (International Trade Administration, 2020).

Korea's success factors

The success story of Korea is not accidental. It is the result of a combination of factors that involved a dramatic economic turnaround, the government's clear vision for ICT, its political will, and decades of intervention and investment in education and modern technologies.

Economic transformation

After the Korean War in the 1950s, Korea was one of the world's poorest economies: its economy (developed without the benefit of natural resources such as oil and instead relying mainly on manufacturing and exports of machinery and electronics) had a per capita income of less than US$100 (ITU, 2013c). Over the four decades that followed, Korea averaged an annual economic growth rate of 8 percent, mainly driven by its manufacturing and exports sectors. The economic miracle of Korea definitively created a burning platform for the expansion of its ICT sector. Telephone services moved from being used mainly for political and military purposes to playing a fundamental role in the country's rapid economic growth and rise in living standards, then propelled the drastic upgrade in the telecommunication network infrastructure. Korea's manufacturing-based economy shifted from textiles to chemicals, then to machinery and electronics. Today, Korea is one of the top 20 most competitive nations in the world (13th according to the WEF Global Competitiveness Index), with a per capita income of US$31,350 (Schwab, Zahidi and WEF, 2020). Knowledge and information products and services play a significant role in the economy, making the country not only a global innovation powerhouse. Korea is the second largest investor worldwide in research and development (R&D) dedicating yearly US$91 billion or 5 percent of its GDP, and it is also the country with the highest macroeconomic stability in the world (Schwab and WEF, 2019).

Regulatory policies

In the 1980s, important changes in Korea's regulation took place. The government's leading role in the development of Korea's ICT sector reached a tipping point in 1982, when Korea Telecom (KT) was separated from the Ministry of Communications, and investment was directed to rural regions to minimize gaps with relation to urban areas. As investment was already made in analogue telephone switches in the cities, rural areas were targeted for the latest digital technology. The government also pushed the development of a locally produced telephone exchange (TDX) to reduce dependency on imports. The numbers of local call areas were reduced, and a national flat rate usage tariff became a policy goal. Urban installation charges were raised and rural lowered. In terms of telecommunications funding, several laws were established to raise capital from bonds. Tariffs were structured to maximize investment funding and public national investment in the telecommunications sector was increased from less than 3 percent up to 7 percent.

Since 1987, the Korean government has spent more than US$5 billion in connectivity efforts. In that year, the *Framework Act on Informatization Promotion* was created with the goal of contributing to the realization of a sustainable knowledge-based society. The framework established and prioritized the national broadband deployment plan. Also in 1987, the Korean government started computerizing national data such as resident and real estate registration and finances, as part of its efforts to lay the groundwork for computerization at the national level. The Korean government also launched master plans for basic computerization and national backbone networks. Another significant step was signing the World Trade Organization (WTO) agreement on basic telecommunications services, which became effective in November 1997, and which committed the country to the liberalization of its telecommunications sector. In the 1990s, the government also started the privatization of KT, opened market segments and created a Ministry dedicated to the sector (the Ministry of Information and Communication , or MIC) and an agency to promote digital opportunity, the Korean Agency for Digital Opportunity and Promotion (KADO). KADO aimed at increasing access to the Internet, and supplying digital literacy training to over 10 million people, including the most vulnerable populations.

The Korean government also adopted policies for supporting facility-based competition, including the following:

- In 1995, broadband was classified as a value-added service to the economy.

- In 1998, Thrunet (a new entrant, different of the incumbent operator KT) was the first one in the country introducing broadband services.

- In 2002, KT was privatized, a quality monitoring system for broadband was implemented, and local loop unbundling (LLU)10 was introduced. This had the effect of encouraging competitors to develop their own broadband infrastructure, rather than relying on the incumbent’s, to enhance intermodal competition between asymmetric digital subscriber line (ADSL) and cable, and to expand broadband availability in rural areas (Fransman, 2006).

In terms of quality provision and accessibility, in addition to subsidizing the price of connections for low-income and traditionally unconnected people, the Korean government also introduced effective measures and programs:

- In 1999, a network certification program for broadband Internet-installed buildings. Four different "classes" (Premium, Class 1, Class 2, and Class 3) according to speed provided (1Gbps, 100 Mbps, 50 Mbps, 20 Mbps).

- In 2000, a free basic IT training program for 11 million citizens (21 percent of the population) was implemented. Target clients included teachers and students, as well as vulnerable sectors of the population: farmers, fishermen, labor workers, housewives, soldiers, public officials, elderly, disabled, and prisoners.

In addition to the above, the Korean government also became a role model in the adoption of broadband, developing one of the most advanced e-government services in the world. Complementary to the laws and regulations launched in the 1980s and 1990s for efficient computerization, the Electronic Government Act (2001) also helped bring Korea forward in becoming one of the world’s largest cybermarkets. In 2008, Korea’s cybermarket transaction volume was of US$44 billion (Min, 2010) and ranked first in the UN 2010 Global e-Government Survey, achieving the highest scores in both the Online Service Index and the e-Participation Index (UN, 2010). In 2018, Korea ranked first (together with Denmark and Finland) on the e-Participation Index and third on the overall e-Government Development Index Survey (UN, 2018).

Private sector role and cooperation with government

The private sector has had an important role in the provision of fast affordable Internet in Korea. Carriers did an important part of the structural work and have always tried to work in collaboration with the government. The Korean government influences the market, but it does not dominate it; it plays a significant role in counteracting market failures and in motivating the private sector to make long-term investments by providing public guarantees and protection. Government and business representatives work together and there is almost no government project which is not carried out without the cooperation of the private sector.

[10] LLU is a regulatory process consisting of allowing multiple telecommunications operators to use connections from the telephone exchange to the customer's premises.

The government has not only provided funds at very low interest rates to private companies so they could invest in broadband access, but has also attached very interesting conditions to achieving its goals of narrowing the digital divide. One example is the funds provisions in 2000, which required companies to invest in less densely populated areas. This measure reduced the risk taken on by the facilities-based service providers (FSP) and generated spillover effects close to over US$7 billion and around 8,000 new jobs in only one year (ITU, 2013c). Another example of joint collaboration was the investment into the country's multimedia network. In 2003, the South Korean Information and Telecommunication Ministry together with the nation's largest carriers invested US$2.1 billion into this network (Lee, 2017), securing a US$1.2 billion investment from these carriers until 2010. The government also embraced infrastructure sharing and encouraged market competition as a way to increase competition in the broadband market. These measures have proven very effective as private sector companies compete by offering lower prices for a faster Internet, which in turn brings many benefits to the end user. Lastly, the Korean government also allows private companies to experiment with new technologies without taking on the financial risk. The government's Security Net program (KISA, 2016) provides companies with support for research on next generation Internet technologies.

Education

Education has always been regarded as an essential building block of the nation's progress and its socioeconomic development. Over decades, the Korean government has continuously expanded the provision of free education to all students. Korea's overall school enrollment rate is one of the highest in Asia and the world (above 90 percent in primary, secondary, and tertiary education, according to the World Bank's World Development Indicators). Teachers in Korea are highly respected, and the teaching profession is one of the most sought after by highly skilled students. The amendment of the Lifelong Education Act in 1999 was targeted at improving Korean's quality of life and enhancing the social capacity, thus preparing the basis for a lifelong learning society (Ministry of Education of Korea, 2015).

In regard to educational attainment, Korean students have a successful track record in leading the rankings of international tests such as the Program for International Student Assessment (PISA) and the International Association for the Evaluation of Educational Achievement's test on Trends in International Mathematics and Science Study (TIMSS). Education in Korea is not only top of the world but also highly digital and aligned with the needs of the fourth Industrial Revolution. Korean classrooms have wireless Internet, electronic blackboards, virtual reality devices, digital textbooks, and personal computers (PC). The government has also implemented diverse policies to financially support the research centers of its country universities. Korea also ranks very high in the number of papers published in scientific journals (Ministry of Education of Korea, 2015). By investing in Education and ICT literacy, the federal government also contributed to the expansion of broadband creating a healthy cycle of demand and supply in the country's digital landscape.

Additional factors

Other factors that helped accelerate the expansion of broadband Internet in Korea are as follows:

- Sociocultural characteristics: community orientation, using the language barrier to develop localized content, restless attitude, and a can-do spirit.
- Korea's population density: more than 50 percent of the population live in apartments, simplifying efforts for broadband deployment.
- Proximity to telephone exchanges: average distance from a customer to a telephone exchange being about 2.2 km.
- Equipment: low prices due to Korea's manufacturing industry driving competition.
- Internet pricing: Korea has some of the lowest broadband Internet prices in the world and one of the highest Internet speeds. Broadband pricing is flat rate, and uniform across providers (around US$30 per month).
- Project management and evaluation: the Korean government constantly collects data, carries out surveys and reports to measure the effectiveness of the programs it launches. There is also a solid evaluation system for national ICT projects and a series of ICT related plans, which have paved the way to the expansion of broadband in the country.

With regards to mobile communications, despite Korea being relatively slow in the introduction of digital services, today it also has one of the highest rates of mobile penetration in the world. The success was again a result of close cooperation between the government and the telecommunications corporations. An example of this was the introduction and use of the code division multiple access (CDMA) service, which was also crucial to the growth of Korea's telecommunications industry. In the 1980s Korea started developing mobile services through the Korea Mobile Telecommunications Service Corp (KMTSC), now part of the SK Group). KMTSC had a monopoly in the provision of cellular services with a very low penetration rate. After its privatization, the market became competitive and Internet/broadband penetration rapidly grew in the 1990s when new operators entered the market.

The future: Challenges and opportunities

Having universal access to the Internet provides a foundation for developing new technologies and cloud-based services. This, combined with Korea's continuous ICT spending and investment in R&D, is giving the country an early mover's advantage for the creation of a vibrant digital economy and the opportunity to focus in other areas such as artificial intelligence (AI), IoT or the development of Smart Cities.

Projects for community safety, traffic improvement, urban living, and energy conservation, as well as IoT led solutions are some examples of where Korea's digital opportunities lay. All these focus areas require faster Internet speeds, which 5G is expected to deliver. In April 2019, Korea launched the 5G standard and by the end of June of the same year, according to Global System for Mobile Communications Association's (GSMA) data, more than 1.6 million people (77 percent of the global 5G users' population) had already made the switch (Jung-a, 2019). Despite the excitement, 5G is still settling down and it needs to be improved in order to deliver the ultrafast speed it promises. Even though large investments have been done by operators such as KT Corp., SK Telecom, and LG Uplus, who jointly put in around US$2.6 billion in 2019 in the technology, more investments in base stations infrastructure and new content are needed. Again, the cooperation between government and the private sector has been fundamental. For example, to support 5G investments, the government offers operators a tax credit of 1 to 3 percent for a two-year period to reduce CAPEX burden. The government is also providing financial support in the form of loans and funds for 5G startups. The government also puts at the disposal of operators 23 5G test beds focused on key mobile broadband connectivity enablers and applications, such as vehicle-to-vehicle (V2V) or vehicle-to-everything (V2X) and drones. The Korean government estimates the country will generate US$109 billion from the production of goods and services in 5G related industries by 2026, which corresponds to 15 percent of the total market share (Waring, 2019).

Table 3.2. Korea's Success Factors at a Glance


▪ Strong national leadership, integrated and sounded National Broadband strategy and government's long term strategic planning.
▪ Government making lead investments, and bearing the risk
▪ Consistent policies with strong project management and project evaluation tools
▪ Successful top-down demand creation: government as a model user
▪ Creation of highly competitive market environment
▪ Collaborative approach with the private sector
▪ Availability and affordability of popular applications
▪ Investment in education, ICT literacy and, R&D
▪ Creative incentives for investing in last mile and rural connectivity
▪ Income from license fees reinvested in the ICT sector
▪ Socio-cultural and geographic/demographic advantage
▪ ECOSYSTEM view: integrated, holistic approach to broadband development by viewing it as more than a simple network

Source: Authors' elaboration.

Global Case Study: Spain

Table 3.3. Country Profile: Spain

COUNTRY FACTS	ICT FACTS
Total land area: 505,900 km^2, of which 432,138 km^2 are rural areas	**Mobile cellular subscriptions per 100 people:** 115.9
Population: 46,720,000, of which 80 percent lives in urban areas	**Mobile broadband subscriptions per 100 people:** 98.5
Population density: 93.5 per km^2	**Fixed broadband Internet subscriptions per 100 people:** 32
GDP: US$1,426.19 billion	**Fiber Internet subscriptions per 100 people:** 14.4
GDP per Capita: US$30,530	**Individuals using the Internet (percentage of population):** 86.1 percent
Rank in Global Competitiveness Index: 23 of 141 economies	**Internet affordability:** Fiber Internet, broadband up to 30 Mbps at US$47.1 a month; more than 100 Mbps at US$66.7
School enrollment, primary (gross percentage): 102.7 percent	**Internet speed:** 36.23 Mbps mobile download; 125.18 Mbps fixed broadband download
School enrollment, secondary (gross percentage): 126 percent	**Rank in the ITU ICT Development Index:** 27 of 176 economies
School enrollment, tertiary (gross percentage): 88.85 percent	**Overall rank in The Economist Inclusive Internet Index:** 10 of 100 countries

Sources: EC (2015); ITU (2017); Schwab and WEF (2019); Speedtest (2020); The Economist Intelligence Unit (2020); Trading Economics (2020e); UNESCO Institute of Statistics (2021d); World Bank (n.d.e).

In a short amount of time, Spain has taken a leading role in the area of Internet connection and communication technologies. The first networks appeared in Spain in the 1960s to support some of the activities in its banking sector. Data networks were introduced by the Spanish National Telephony Company (Compañía Telefónica Nacional de España, or CTNE) now known as Telefónica, which had the monopoly in fixed telephony services. The developments that took place in the decades that followed were mainly pushed forward by the academic and scientific communities, who wanted to connect their computing resources and facilitate information exchange (Pérez Martínez, Frías Barroso, and Urueña López, 2018).

The launch of the Telecommunications Ordination Law in 1987 and the launch of the Infovía service by Telefónica framed the beginning of Spain's history in the development of residential Internet at a bigger scale. During the 1990s, several laws were introduced to liberalize the telecommunications sector. With this, several ISP entered the market and Telefónica was privatized. Mobile telephony services were also introduced and competition started to flourish in the sector.

In the early 2000s, there were already 600 Internet providers operating in the territory, new regulatory bodies such as the Telecommunications Market Commission (CMT) were created, and Spain would adjust its legislation to the EU legal framework. In 2004, home Internet access was at 33 percent, but in 2008, two years after the launch of Plan Avanza (Spain's National Broadband Strategy), Spain was still behind its European peers (14th place) in terms of broadband access. Spain then decided to take a risk by investing billions of euros in modern fiber technology at a very difficult economic time. The financial crisis had cut its GDP in half and unemployment rates were at a historic high with more than a quarter of its population (specially the youngest) out of work. In 2014, home Internet access was at 80 percent and Spain jumped to number one in Europe in FTTH connectivity. In a relatively short period, telecommunications' operators in the country laid out fiber optic cable reaching more than 31 million premises (more than France, the UK, Germany, and Italy combined) (Medina, 2017).

In 2015, mobile Internet access was over the EU average at 80.33 percent and Spain's digital economy was almost 20 percent of its GDP. By 2016, about 64 percent of Spanish households had access to ultrafast broadband. Although Spain is still not one of the world leaders in Internet access and affordability, it positions high in many global indexes. For instance, Spain is the fifth country in the EU and eighth in the world in Internet inclusion (The Economist Intelligence Unit, 2020). Within the EU, the country ranks first on readiness and second on availability (The Economist Intelligence Unit, 2020). Today, the optical fiber network deployed in Spain is the widest in Europe with more than 33.3 million access points, covering more than 75 percent of the population; the coverage for 4G coverage is over 95 percent (EC, 2020a).

Spain's success factors

The key to Spain's success in broadband access can be linked mainly to three components: regulation, financial mechanisms, and the introduction of gradual but steady competition.

Regulatory policies

Spain has worked hard in removing regulatory and administrative barriers as well as in ensuring a dynamic use of spectrum to promote the deployment of ultrafast broadband networks. Spain's National Broadband Strategy (Plan Avanza) launched in 2005, created the framework and vision for a telecommunications sector (Ministry of Industry, Tourism, and Commerce of Spain, 2010).

The ambitious Digital Agenda for Spain (or Agenda Digital para España) launched in 2013, gave continuity to the strategy laid out in the Plan Avanza and established the framework and roadmap for Spain to achieve the strategic goals established in the Digital Agenda for Europe (DAE) and its 2020 vision. With the Digital Agenda for Spain, the government introduced another important measure to foster the deployment of networks and services by setting up a regulatory framework that guarantees certainty and prevents the introduction of unnecessary barriers. It also provides strategies to deploy ultra-fast networks and an efficient radio spectrum management, as well as mechanisms for improving the experience of broadband service users, increasing the demand for digital services and e-commerce, and promoting the creation and distribution of digital content. Its goals include 100 percent coverage of 30 Mbps and 50 percent take up of 100 Mbps and more of households by 2020.

The 2014 Spanish Telecommunications Law was another measure introduced by the government to guarantee the achievement of the objectives of the Digital Agenda for Spain, as well as those of the DAE and its 2020 vision. The law also reduced regulatory and administrative barriers, which resulted in a more favorable environment for investments in ultra-fast networks.

All these initiatives and regulations, especially the asymmetric obligation to access Telefónica's conduits and the symmetrical obligation to share vertical infrastructures inside buildings, have facilitated the deployment of Spain's new generation networks. With 37.6 million FTTH accesses deployed in the territory, Spain is the EU country with the largest number of homes that can connect to this network. In total, 9.6 million customers hire new generation broadband accesses (FTTH and DOCSIS 3.0) and the speeds offered by operators reach up to 1 Gbps (CNMC, 2017).

Another interesting regulatory measure Spain adopted was in relation to increasing coverage in underserved areas. Spain's Broadband Extension Assistance Plan (Programa de Extensión de Banda Ancha, or PEBA), was one of the projects included in the country's National Broadband Strategy specifically tailored to rural areas. In its initial years, 29 projects were implemented by two operators (Telefónica and Telecable) with a total budget of US$102 million. Since 2013, PEBA has provided high-speed connectivity to 2.8 million households (EC, 2020e). Some interesting factors of this program included the following:

- The financing of projects was technology independent (fixed or mobile) but based on the solution most adequate for the region in question. It comprehends ADSL (86.3 percent), WiMAX (5.1 percent), satellite (8.4 percent), and hybrid fiber coaxial (HFC) (0.2 percent).
- Subsidies granted to operators to increase coverage of Next Generation Access Networks (NGA) in underserved areas. Of the total US$102 million budget, the Ministry of Telecommunications and Transportation provided US$20 million in zero-interest loans and US$9.5 million in grants to European Region Development Fund objective 1 regions.

- Establishment of clear key service requirements in:
  - Minimum bandwidth (256/128 Kbps).
  - Price caps equivalent to US$44.5 (one-off sign-up fee) plus US$44.5 (monthly fee) during the 36 first months.
  - Comparable technical characteristics to commercial broadband services.
  - Deployed infrastructures should be open to third parties for at least 3 years (e.g., Digital Subscriber Line , or DSL wholesale obligations on conditions fixed by the telecoms regulator).
  - Deployment objectives were defined and a list of eligible population centers was included in the calls for proposals (OECD, n.d.).

Spanish institutions have also played an important role for broadband development. The country's Secretary of State for Digital Progress, (Secretaría de Estado para el Avance Digital, or SEAD), is the responsible entity for the momentum and coordination of plans, technological programs, and actions for connectivity and digital transformation. It incorporates public policies in telecommunications and leads the political action for strengthening the ecosystem of digital ventures (EC, 2020c).

But it was with the creation of the National Commission for Markets and Competition (Comisión Nacional de los Mercados y la Competencia, or CNMC), in 2013, that Spain moved forward in the consolidation of regulation for the liberalization of the telecommunications sector. Although it is a public entity under the Ministry of the Economy and Commerce, it enjoys independent and legal status and is subject to parliamentary control. It was established with the goal of unifying a series of control and regulatory bodies established in the 1990s. With the creation of the CNMC, the government consolidated efforts and normativity in the telecommunications sector and reduced unnecessary duplication and contradictory decisions in the control of each operator (CNMC, n.d.a). Nevertheless the institution came under criticism for consolidating regulation and competition policy.

Lastly, the Spanish government has also aimed at becoming a driver in ICT adoption by implementing several e-government initiatives for the digitalization of government and public services. In regard to schools, 99.8 percent have Internet connection, of which 90.6 percent counts with broadband access. The municipalities' health systems are interconnected with the National Health Service, which enabled the development of the digital health card, e-appointments and e-recipes, as well as the availability of digital clinical history of patients. Also remarkable is the digitalization of 432 civil registration centers and the introduction of the electronic national identification card (document nacional de identidad, or DNI). Based on these examples, Spain is doing very well in the area of digital public services, having implemented its e-government strategy in good time. As per 2020, it ranked fourth in the EU in this area (EC, 2020e).

Financial mechanisms

A combination of EU funding, state funding, and private investment has been key for Spain's rapid development of its broadband network. In regard to network deployments, there are several EU regulations that restrict the aid that public administrations can provide. In its guidelines, the EC establishes recommendations to avoid duplications and inconsistencies between the deployment plans of the different administrations, and to avoid distortions of competition that could arise from these grants. The EC only allows financing projects in so-called white or grey areas, which are those where there is little probability of private deployment due to apparent low returns on investment. In Spain, there are a total of 60,632 singular population entities from which the Ministry of Industry, Commerce, and Tourism (Ministerio de Industria, Comercio y Turismo Directo, or MINETAD), and Digital Agenda consider 87.4 percent white areas (CNMC, 2017).

Regarding state aid, in the 2013–2017 period, PEBA granted US$246 million of public aid in projects to bring high broadband speed to 3,586,311 homes and businesses, extending these networks to 4,064 unique population entities that had no previous coverage. In 2017, PEBA grants amounted to US$186.8 million. Of this figure, 23.7 percent was financed directly from the Ministry's budget, when in 2016 this percentage was zero and in 2015, 12.6 percent. The remaining 76.3 percent was financed with contributions from the European Regional Development Fund (ERDF).

In March 2018, the Government of Spain announced the 300x100 Plan for Optical Fiber deployment in rural areas, which aims at giving access to ultra-fast broadband networks to 95 percent of the population. It involves aid worth US$599 million for the period between 2018 and 2021, of which 395 are financed through funds coming from the ERDF (CNMC, 2017). In addition, a complementary plan (worth US$51 million) was also launched to guarantee high-speed Internet access for those living outside population centers. Similar initiatives such as the National Smart Territories Plan (2017–2020) and the National Rural Development Program (2014–2020), which imply an investment of approximately US$58 million and US$288 million respectively, are also under way.

Gradual, steady, and collaborative competition

Competition in the Spanish telecommunications market started in the 1990s with the granting of the second mobile phone license to Airtel Móvil (Vodafone). In just four years, Spain passed from a monopoly regime to one of open competition and at the end of 1998, the Spanish Telecommunications market was completely liberalized (five years ahead of the EU directive).

Market liberalization implied a total rethinking of the regulatory bodies overseeing the telecommunications sector including the creation of CMT and its later transformation into CNMC, the privatization of Telefónica, and the enactments of laws aimed at boosting competition. During this stage, the main goal of the government was to promote the entry of new operators in the market and, from the operator's point of view, to capture the largest number of customers in the shortest possible time and with innovative tariff offers.

The competitive broadband market pushed Telefónica to invest in optic fiber in order to transform its services. Operators had access to the needed infrastructure to connect FTTH and landlords were required to provide access to the in-building fiber infrastructure. Spanish regulation also promoted investment from operators by creating incentives for them to roll out fiber networks: operators started rolling out their own networks in speeds above 30 Mbps as Telefónica was not obliged to give other providers access on speeds above 30 Mbps. Telefónica developed additional schemes to regain market share like the introduction in 2012 of "quad-play" (a discounted bundle of mobile, fixed, broadband, and television).

In an attempt to reduce the costs of deployment, Spanish operators also engaged in collaboration mechanisms involving voluntary infrastructure sharing joint agreements to roll out fiber and "coo petition" mechanisms (collaborating through competition). In 2017, Vodafone and Movistar reached an agreement whereby Movistar would offer wholesale access to its FTTH (approximately 14 million units), in exchange for Vodafone accepting rental commitments for a minimum of five years. The agreement set volume discounts and Movistar also opened the possibility to third party operators to participate. This wholesale offer of access to fiber was an important milestone in the Spanish market, both for its volume and its opening to other operators and for including access to Telefónica's fiber network in areas not subject to regulatory obligations.

In addition to the three main success factors explained above, the below measures also contributed to the increase in coverage and broadband availability in Spain:

- The award of three new mobile spectrum concessions in the 900 MHz band. Proposals were valued based on infrastructure investment commitments of the competing operators and not on the magnitude of their contribution to the Treasury.
- The unlocking of 3G mobile licenses, and Universal Mobile Telecommunications System (UMTS).
- The development of a new regulation, which allowed the secondary spectrum market and technological neutrality in licenses, which gave great flexibility to the optimization of the use of frequencies, and in turn generated more coverage, more bandwidth and more economic activity.

- The transition to digital TV, which also released significant amounts of spectrum later used for the expansion of broadband mobile services. In 2009, income generated from spectrum use reached US$25,600 million, 54 percent of the telecommunications and audiovisual sectors total income.

The future: Challenges and opportunities

Although Spain has a very good fast and ultra-fast coverage, there are still significant differences between urban and rural areas which need to be addressed. The Spanish government is working on take-up measures addressed to rural and underserved areas where users may have to face higher upfront costs for high-speed broadband services. Such take-up measures are based on grants allocated to end users, in order to provide access services through any broadband technology capable of reaching 30 Mbps. Various regions have developed their own projects, for digital development and broadband rollout, financed with their own financial resources, private sector investments, as well as with European funds (EC, 2020c).

The deployment of fiber to the premises (FTTP) networks also continues to be an important feature of the Spanish digital market that requires attention. Although the fixed broadband price index for Spain shows a slight improvement, the country still ranks 22nd (EC, 2020e).

In terms of e-government, there are several opportunities to be pursued as Spain's decentralized structure has posed some challenges to a more coordinated establishment of e-government services. One of them, the Digital Transformation Plan for the General Administration and Public Agencies (ICT Strategy 2015–2020) aims to ensure that public administration is electronically accessible by all citizens. The plan sets out the framework for progress in the transition to e-administration in the State's General Administration and its Public Agencies (Administración General del Estado y sus Agencias Públicas).

Other areas of future opportunities are cloud computing, cloud service development, content development, data analytics, and IoT. However, to take full advantage of these, Spain will have to make improvements in its human capital sector, as well as investments in 5G.

In the human capital dimension, Spain ranks 17th out of 28 EU countries and its basic digital skills levels remain below the EU average. Only 55 percent of people between 16 and 74 years of age have basic digital skills (compared with 57 percent in the EU as a whole). The proportion of ICT specialists represents a lower percentage of the workforce compared to the EU average (2.9 percent compared to 3.7 percent in the EU), and ICT graduates in Spain account for 3.9 percent of the total, with female ICT specialists accounting only for 1 percent of total female employment (EC, 2020d).

In 2018, the Ministry of Education and Vocational Training proposed including in all vocational education training (VET) programs a set of modules designed to support the acquisition of skills and competencies in Industry 4.0, big data, communication networks 5.0, and other ICT skills. Another project launched to reduce the ICT skills gap is the School of Computational Thinking, designed to help teachers incorporate computational thinking into their daily practice through programming and robotics. Around 800 teachers and 20,000 students from primary, middle, and high school were expected to participate over 2018–2019. The Ministry of Education and Vocational Training has also launched an initiative called STEMGirls, a repository of international and national initiatives to help and motivate women and girls to choose studies related to Science, Technology, Engineering and Math (STEM), and to overcome the gender gap in technology. The Government (through the Ministry of Employment) has also set up a training plan in digital and technological competencies with a budget of US$68 million. The plan will focus on 12 areas considered to be priorities in 23 sectors of the economy, namely: (i) broadband communications, (iI) cybersecurity, (iii) management and maintenance of 3D printers, (iv) AI, (v) robotics, (vi) drones, (vii) automotive with electric motor or autonomous driving, (viii) cloud computing, (ix) IoT, (x) advanced analytics, (xi) cognitive computing, and (xii) location services. It will be tailored to women, people with disabilities, low-skilled workers and workers aged above 45 years old (EC, 2020e). The Government is also working on the Spain Start-up Nation strategy to embed innovation and digitalization in the economy and society.

In terms of 5G, Spain introduced the 5G National Plan 2018-2020 which is currently supporting the adoption of standards, identifying use cases, and promoting the development of the relevant ecosystems. The ground for 5G deployments is being prepared, with several pilot projects under way. The pillars for a successful implementation of 5G include the following:

- Radio spectrum management and planning.
- Network and service pilot projects and R&D activities.
- Regulatory issues required to provide a flexible legal framework.
- 5G plan coordination and international cooperation.

After the publication of the 5G National Plan for 2018–2020, the Ministry of Economy and Business guaranteed the use of certain frequency bands for 5G pilots and established regulation for granting subsidies to 5G technology pilot projects. In Spain, 47 percent of the spectrum harmonized at EU level for wireless broadband has been assigned.

Spain ranks sixth in 5G readiness, with 30 percent of 5G pioneer bands assigned. By the end of 2018, it had assigned spectrum in the 3.4–3.8 GHz band in accordance with Commission Decision (EU) 2019/235, and the spectrum is expected to become available for use for 5G by 2020 (EC, 2020e; Ministry of Energy, Tourism, and Digital Agenda of Spain, n.d.).

Table 3.4. Spain's Success Factors at a Glance


▪ An ambitious vision for the telecommunications sector with a strong National Broadband Strategy
▪ EU support, funding, and community directives for digitalization of member countries
▪ Consistent policies with strong project management and project evaluation tools
▪ Successful top-down demand creation: initiatives for the digitalization of government (e-government) and public services (specially health)
▪ Creation of highly competitive market environments
▪ Creative incentives for investing in last mile and rural connectivity
▪ Regulatory measures for the early liberalization of the telecommunications sector and for gradually increasing competition (wholesale access to Telefónica's ducts, symmetric access to vertical infrastructure, and geographic segmentation)
▪ Creation of independent regulatory organizations such as the CNMC and consolidation of other control and regulatory bodies
▪ Collaborative competition: co-investment or commercial network sharing agreements (specially in last mile)

Source: Authors' elaboration

Global Case Study: Estonia

Table 3.5. Country Profile: Estonia

COUNTRY FACTS	ICT FACTS
Total land area: 45,300 km^2, of which 40,499 km^2 are rural areas	**Mobile cellular subscriptions per 100 people:** 145.4
Population: 1,320,000	**Mobile broadband subscriptions per 100 people:** 146.7
Population density: 30.4 per km^2	**Fixed broadband Internet subscriptions per 100 people:** 33.3
GDP: US$30.28 billion	**Fiber Internet subscriptions per 100 people:** 11.4
GDP per Capita: US$22,939	**Individuals using the Internet (percentage of population):** 89.4 percent
Rank in Global Competitiveness Index: 32 (out of 141 economies)	**Internet affordability:** fiber Internet, broadband up to 30 Mbps at US$27.8 a month; more than 100 Mbps at US$50.7
School enrollment, primary (gross percentage): 97.2 percent	**Internet speed:** 46.32 Mbps mobile download; 61.61 Mbps fixed broadband download
School enrollment, secondary (gross percentage): 118 percent	**Rank in the ITU ICT Development Index:** 17 (out of 176 economies)
School enrollment, tertiary (gross percentage): 69.64 percent	**Overall rank in The Economist Inclusive Internet Index:** 12 (out of 100 countries)

Sources: EC (2015); ITU (2017); Schwab and WEF (2019); Speedtest (2020); The Economist Intelligence Unit (2020); Trading Economics (2020d); UNESCO (2021c); World Bank (n.d.c).

Estonia is often held as the most digitally advanced society in the world with a digitally raised young population. Ninety percent of government services are online, and it possesses one of the best performance levels in terms of Internet usability, relevance, and readiness (France24, 2019). Tallinn, the country's capital, has transformed itself into a technological hub as attractive as London, Paris, Berlin, or even Silicon Valley. It hosts companies valued over US$1 billion (the so called "unicorns") and provides a very stable macro-economic environment for the establishment of entrepreneurs. It is estimated that Estonia's ICT sector contributes to almost 20 percent of the country's exports (Mills, 2017).

Estonia's success factors

Although Estonia is a very small nation, with a small population and very unique conditions, there are several lessons that can be drawn from Estonia's success, which are replicable to any other country.

Government mentality and focus in ICT and education

In 1991, when Estonia gained independence from the Soviet Union, it found itself at a very difficult crossroad, both economically and socially. Less than half of its population had a telephone line, and GDP was low. The government decided that a digital economy and a massive investment in technological innovation was the way forward. Then, it started to develop and to adopt a series of measures to modernize the economy and to move fast into the future instead of going slowly: a flat-income tax was introduced, as well as free trade, investment, and privatization. New businesses could register smoothly and without bureaucratic burdens. The country quickly caught up with its EU neighbors and soon would become one of the Baltic Tigers (along with Latvia and Lithuania).

The government also took an interest in the digital approach from the start. Instead of upgrading old legacy technology or taking in archaic telephone technologies given to them for free by more powerful and richer neighbors, Estonia decided to build a digital system of its own. Estonian politicians decided to "skip certain things" and to "ditch legacy thinking" (A.A.K., 2013), thereby taking a "Tiger Leap" into the future and betting on business, ICT training and technology as their key levers to boost economic growth. Some of the initiatives undertaken included the following:

- "Tiger Leap" program launched in 1997 to provide all the country's schools with ICT infrastructure, and to support content creation and the acquisition of usage skills.
- Introduction of coding lessons in the curricula for kids aged 6 and above.
- Provision of free ICT training to 10 percent of the population. Estonia is today one of the very few countries where there is no gender gap and where disadvantaged people are less exposed to the risks of digital exclusion.
- Making Internet access a human right for all Estonians.

These and other measures made possible that Internet usability in the country increased from 29 percent in 2000 to 91 percent in 2016 (Schulze, 2019). The founding of Skype in 2003 by Estonian engineers and physicists, and its subsequent sale to Microsoft is also regarded as one of the major milestones in the country's ICT race. It brought money back into the economy as many investors reinvested their earnings into the technology sector. The creation of other notable startups like TransferWise and Jobbatical helped uplift the entrepreneurial spirit of Estonians and their "we can do" mind set.

Broadband Strategy and Digital Agenda 2020

Estonia's Broadband Strategy and its ambitious Digital Agenda have also been important drivers in the country's digital success story. They aimed at deploying the next generation of broadband networks by 2020 giving all residents access to fast (more than 30 Mbps) Internet with at least 60 percent of households using ultrafast (more than 100 Mbps) Internet daily. It also considers the establishment of last mile connections in areas with market disruption, particularly in rural areas. One key measure to achieve the national targets is the Estonian Wideband Infrastructure Network (EstWin), a project launched in 2009 by the Ministry of Economic Affairs and Communications. The project is a passive middle mile network, which does not employ electricity consuming devices and requires operators to deliver the end-user connection. Using micro-duct technology, this fiber optic network rents fiber pairs to ISP. If operators want to provide services in remote places, they will rent "dark fiber" (optical fiber that is been laid out but not been used for fiber optic communication) from the government. Operators then use their own devices to provide the services (EC, 2019b). EstWin aims at rolling out 6,600 km of optical cables in rural areas and settlements with more than 10,000 habitants where optical networks did not exist and are not planned by operators. After completion, 98 percent of all residential buildings, companies, and public authorities will be located within 1.5 km from the EstWin network. All existing network nodes should be connected to core networks. These networks are rolled out by nonprofit organizations and are required to provide wholesale access on equal terms to all operators and public authorities. Approximately 85 percent of the project costs are financed by the ERDF, while the remaining 15 percent of the network construction cost is co-financed by backhaul network operators. By the end of 2017, 5,300 km of backhaul network had been rolled out and approximately 1,700 network nodes had been connected (EC, 2018b).

Other measures developed in parallel to Estonia's Digital Agenda 2020 include the following:

- Reducing administrative burden related to the construction of a communication network by simplifying the relevant legal framework.
- Obligatory installation of last mile connections in new buildings, which are part of state-funded development projects.
- Promoting community initiatives for the development of fast Internet connections.

Estonia's investment in its Digital Agenda 2020 is estimated to be US$254 million. To date, basic broadband coverage has been established throughout the country, bringing its broadband targets for 2020 in line with those of the DAE (EC, 2020b).

Continuity of policies and cooperation with private sector

One common denominator that has remained since the country's independence from the Russian Federation is the government's backing of the notion of a digital Estonia. Despite changes in government and political leadership, the goal of an electronic nation has persisted as well as collaboration with the private sector, and the research community as mechanisms for achieving this goal. An example of this collaboration is the Look@World Foundation. Established in 2001, this partnership of 10 public and private companies aims to support education, science, and culture by encouraging and popularizing the use of Internet and ICT. Supported by telecommunications and banking interests (Roonemaa, 2017), the collaboration focuses on ICT skills, the use of ICT after school, and safe use of ICT. As such, the foundation has helped raise digital awareness and popularized the use of Internet.

Another example of a unique and successful PPP is the ProgeTiger Program. Launched in 2012 with the aim to train teachers and develop materials for ICT learning, today it has transformed into a technology program widely targeted at engineering sciences, design and technology and ICT. It is aimed at integrating technology into the curricula of preschool, primary, and vocational education, offering teachers educational resources and training opportunities, and financially supporting kinder gardens and schools in acquiring ICT devices.

Collaboration with the Estonian society at large has also been key in the transformation of Estonia into a digital nation. The state gained the confidence of its citizens by putting in place transparency and accountability mechanisms to allow citizens to monitor who accesses their data, when, and for what purpose.

A final aspect worth mentioning respects the active role that the "free sector" of Estonia has played in shaping open governance and e-democracy. Policy debate takes into account public inputs, which are channeled digitally through three different portals created for this purpose and funded by taxpayers' money. In 2016, Estonia became one of the countries which best include non-governmental organizations (NGO) in the process of consulting the open government plan of action. Last year, citizen initiative portal Rahvaalgatus.ee was launched, making it possible to compose and send collective initiatives to the Estonian Parliament (Roonemaa, 2017).

Innovative ways of attracting talent

Estonia has demographic challenges: almost half of its population is of working age and due to the geographical size of the country, immigration cannot be conducted in the way other countries do it. Understanding that human talent is the backbone of Estonia's progress and future development was essential for the government to approach the demographic problem differently and once again, take a digital angle to attract talented people into its virtual space. Some of the initiatives launched include the following:

- e-residency program: It allows any person in the world to start a company in Estonia, even if one is not a resident of the country. E-residents receive a government issued digital ID and full access to Estonia's public e-services. They can also benefit from the EU single market without actually living in it. This allows entrepreneurs to establish a trusted EU business with all the tools needed for global expansion. In 2014, Estonia became the first country in the world offering e-residency; to date, more than 50,000 people have applied for the program (Schulze, 2019).

- Digital Nomad Visa: This is another government initiative launched with the aim to attract high-skilled workers from around the world and lure them into establishing their digital enterprises in the country. It gives digital nomads the right to come to Estonia, live and work for up to a year, and the possibility to travel to other EU countries for periods up to 90 days.

- Estonia Startup Visa: Initiated by the local startup community and the Estonian Ministry of Interior together with Startup Estonia, this type of visa allows non-EU nationals to come and work for Estonian startups, relocate their existing startups to Estonia, or found a new one in the Baltic country. The visa may be issued for one year and extended for up to 183 days (thus, for a total of 18 months). After this period is over, it is possible to apply for a temporary residence permit for entrepreneurship, which may be issued for up to five years. This is another government initiative that aims at attracting foreign talent to develop and nurture Estonia's startup ecosystem.

Smarter governance

Getting independence from the Soviet Union enabled public administration and government to work more efficiently. Estonia could no longer maintain the financing and bureaucracy its public administration used to have in the past. Smarter governance was the strategy of choice adopted by its leadership to improve the competitiveness of the state and the well-being of society whilst freeing government from archaic and inefficient processes. That is how Estonia started transforming itself into an electronic society and into a world leader for digital public services. Today, with 99 percent of its public services available online 24 hours a day, the seven days of the week, Estonia is regarded as one of the champions of Europe (earning second place in 2019) for online provision of public services according to the Digital Economy and Society Index (DESI) (EC, 2019a). The share of e-government users (96 percent) is the highest in Europe (double the EU average), and the government prides itself in confirming that 46 percent of its citizens vote online, 99 percent of prescriptions are issued electronically, and that it takes under five minutes to fill taxes online. Aside from marrying, divorcing, and buying a house, Estonians can do pretty much everything online.

Two decades ago, the panorama was quite different. The population in Estonia had no access to Internet or even devices where to use it (half of its population did not even own a phone line). There was no digital data being collected about the citizens, and the paper-driven processes in the government were slow and inefficient. The government then developed a vision for an electronic nation and started a movement to modernize institutions, make processes more efficient, and facilitate citizens' interactions with the government through the use of electronic solutions. The pioneering advances made by the government under the e-Estonia movement fostered ICT investment, innovation in education, virtual business, and digital citizenship. Several programs and initiatives were created to digitalize public services, some of which are detailed here below:

- Digital ID: Every Estonian is issued a digital ID, paired with digital signatures and people's mobile phone, which citizens use for online voting, address registration, request child-birth allowance, check education registry, tax payments, and to access their healthcare records. The impact of digital government has been huge: it has saved the government 2 percent of GDP per year in salaries and expenses (Schulze, 2019).

- e-Health: The country has become a leader in e-Health. Each person in Estonia who has visited a doctor has an online record that can be tracked through a central system. Health records can be shared among doctors using a single electronic file, which can also be accessible to the patient at any point in time. To this it must be added that 95 percent of health data are digitized, as well as 99 percent of prescriptions are digital as it is 100 percent of billing. The e-Prescription system takes data from the national health insurance fund, so if the patient is entitled to any state medical subsidies, the medicine is discounted accordingly. People no longer need to visit a doctor or hospital for repeat prescriptions (EC, 2018b). Blockchain technology is used to guarantee the integrity of stored medical records as well as system access logs.

- e-Tax and administration processes: Efficiency improvements have also been done in the area of taxation, collection, and reporting. Filing a tax declaration online in Estonia takes on average five minutes and a refund is issued within five days (compared to three to six months for a declaration on paper). The success of making public services online can be attributed to the adoption of electronic ID-cards, and the creation of a digital information infrastructure, the X-Road, which allows decentralized databases and information systems to communicate with each other securely. A recent paper by the World Bank (Vassil, 2016) quantified the time savings coming from the adoption of the X-Road as an impressive 2.8 million total hours for 2014, or 3,225 years. The productivity gain from e-government services is equivalent to 3,225 people working 24 hours, seven days a week for a whole year (EC, 2018b).

- i-Voting: In 2005, Estonia became the first country to allow online voting in a nationwide election. Estonian open-source voting is simple and secure. Yet, the major cyberattacks experienced by the country in 2007 rang an important bell and prompted government officials in Estonia to improve their cybersecurity regulations. Estonia helped launch a branch of the North Atlantic Treaty Organization (NATO) to prevent the occurrence of similar attacks. Copies of all of Estonia's data are stored since in a "data embassy" in Luxemburg and the concept of "cyber hygiene" was added to the curriculum of elementary schools. The government has also distributed highly crypted architecture for all the digital government programs and has created a digital information infrastructure (the X-road), on which decentralized databases and information systems can communicate and exchange information securely. Blockchain technology, which is used to guarantee data integrity, and the frequently run government security tests have also given Estonians the necessary confidence to have their own personal data stored on the government's cloud. Today, Estonia is the EU leader in the ITU Global Cybersecurity Index (Hankewitz, 2015).

The future: Challenges and opportunities

Despite tremendous progress in developing public initiatives to strengthen the country's digital public service delivery, Estonia continues to face important challenges. Some of the most pressing concern limited broadband infrastructure and limited human capital development. Notwithstanding, Estonia is in a unique position to make the most of digital technologies with bright opportunities laying ahead.

Expansion of its broadband infrastructure

Although Estonia scores very high in digital public services, followed by use of Internet and human capital, it still falls behind its European peers in terms of fixed broadband market, with a coverage of 89 percent mainly because of low rural availability. Some of the decrease in the last two years in terms of broadband coverage is due to the closing of wireless local loop services that used CDMA 450 technology. These fixed wireless networks have been taken over by mobile network data services. In terms of mobile coverage, Estonia performs very well with 96 percent of the population already using 4G and mobile broadband take-up reaching 133 subscriptions per 100 people. Deploying broadband in rural areas continues to be a challenge. The successful completion of the EstWin project is therefore critical to improve connectivity even in remote parts of the country (EC, 2018b).

In addition to initiatives such as EstWin, Estonia initiated the creation of the Nordic Institute for Interoperability Solutions—an international development center for the joint development of X-Road, e-identity, digital signature, and other components of the basic e-services infrastructure.

Estonia needs to further develop its key public digital infrastructure (i.e., X-Road) to sustain the growth of present and future enterprises and startups.

Further investing in education and human capital

With regards to education and human capital, a recent review by the OECD (Santiago et al., 2016) identified policy priorities to improve the effectiveness of the Estonian school system. These included: consolidating school networks, promoting professionalism of teachers and school leaders, targeting extra resources for students with special education needs and Russian-speaking students, and making vocational education a more attractive option. The most critical problems of the Estonian education system are related to teachers. Teaching is not yet an attractive profession in Estonia and there is low availability of mathematics and physics teachers. Several initiatives have been launched to address the problem, including raising teachers' salaries, creating a new, competency-based career model, establishing competence centers in universities to support professional development and research on teaching practices, and encouraging co-operation among teachers within and between schools (OECD, 2016).

The digital plans for basic schools aim at improving the organization of courses and developing skills with digital tools. These plans map opportunities for improving the planification of courses through the implementation of digital equipment and for developing the digital skills of teachers and pupils. In 2017, two projects were implemented for improving citizens' digital skills. The e-community project aims to develop a sustainable network of training centers based in local libraries, educating more than 1,000 librarians in basic technology usage, e-services, social media, and cybersecurity. The DigitalABC project focuses on people working in the manufacturing industry and provides training in basic digital skills to raise their confidence in using technology.

Other opportunities

- Estonia's 5G Connectivity plan: It is included in the Digital Agenda 2020 as an essential component for establishing the uptake of next generation wireless communication networks in the country. Public auctions will be held in the 700 MHz and 3.5 GHz frequency bands. Estonia also aims at participating in international cooperation projects with Poland, the Nordic and Baltic countries.

- More ambitious targets for e-government services: Focusing on one interaction only, and in raising the capabilities of the public sector for using data analytics and research.

- Adoption of AI applications in the public sector.

- Increasing the supply of ICT specialists and the acquisition of higher ICT skills.
- Acceleration of programs for Cyber security and e-governance, as well as expansion of the e-Residency program.

Table 3.6. Estonia's Success Factors at a Glance


▪ "Tiger Leap" mentality. Focus on digital VVV from the beginning
▪ Investing in advanced and home-developed technology as opposed to upgrading legacy tools
▪ Shed off legacy thinking, integrating government reforms to reduce bureaucracy and unnecessary processes while at the same time digitizing government services
▪ Open mind and resourcefulness for developing regulation to attract global talent to live and create enterprises in the country
▪ Investment in ICT and education, and development of public private partnerships for strengthening these sectors
▪ Ambitious National Broadband Strategy and alignment with the EU guidelines
▪ Entrepreneurial top-down mentality, beginning with the government whose risk prone attitude and willingness allows them to experiment
▪ One vision for a digital nation with continuity of policies that address that vision despite changes in political leadership
▪ Generating trust in ICT usage through the collaboration with society (e.g., citizens giving access to personal data and creating transparency and accountability mechanisms)

Source: Authors'elaboration.

Regional Case Study: Ecuador

Table 3.7. Country Profile: Ecuador

COUNTRY FACTS	ICT FACTS
Total land area: 256,400 km², of which 244,458 km² are rural areas	**Mobile cellular subscriptions per 100 people:** 92.3
Population: 17,080,000, of which 35.78 percent of people live in urban areas	**Mobile broadband subscriptions per 100 people:** 54.7
Population density: 68.8 per km²	**Fixed broadband Internet subscriptions per 100 people:** 11.4
GDP: US$108,400 billion	**Fiber Internet subscriptions per 100 people:** 1.6
GDP per Capita: US$6,346	**Individuals using the Internet (percentage of population):** 57.3 percent
Rank in Global Competitiveness Index: 90 (out of 141 economies)	**Internet affordability:** US$2.61 per Mb per month for fixed Internet; US$6.93 for 1 GB for mobile Internet. 9 percent for fixed broadband and 7 percent for mobile broadband.
School enrollment, primary (gross percentage): 103.5 percent	**Internet speed:** 21.03 Mbps mobile download; 27.32 Mbps fixed broadband download
School enrollment, secondary (gross percentage): 102 percent	**Rank in the ITU ICT Development Index:** 97 (out of 176 economies)
School enrollment, tertiary (gross percentage): 44.9 percent	**Overall rank in The Economist Inclusive Internet Index:** 54 (out of 100 countries)

Sources: IDB (2020); ITU (2017); Schwab and WEF (2019); Speedtest (2020); The Economist Intelligence Unit (2020); Trading Economics (2020c); UNESCO Institute of Statistics (2021b); World Bank (n.d.b).
Note: Data for 2019. In 2020, Ecuador was not listed in this Index.

In the last decade, Ecuador has seen a gradual but steady evolution in the deployment of broadband and Internet technologies. Narrowing the digital divide has been a priority of Ecuador's government and of its Ministry of Telecommunications and Information Society (Ministerio de Telecomunicaciones y de la Sociedad de la Información). According to an analysis conducted by this Ministry between 2005 and 2012, broadband access in Ecuador contributed to poverty reduction and employment generation (Rivera Zapata, Iglesias Rodríguez and García Zaballos, 2020). The annual increase in the income level after the introduction of broadband was 3.67 percent. The study also showed that a 1 percent increase in broadband penetration boosted the employment rate in Ecuador by 0.056 points and lowered the unemployment rate by 0.105 percent.

Based on these results, the increase in broadband penetration from 4.19 to 5.21 percent in 2012 generated more than 85,000 jobs, of which previously unemployed individuals filled 6,960, and those previously economically inactive or underemployed filled the other 79,394 (Katz and Callorda, 2013). The study also shows that a surge of 10 percent of broadband penetration in the country contributes to a 0.52 percent GDP increase (Ministry of Telecommunications and the Information Society of Ecuador, n.d.a).

One of Ecuador's national objectives is to provide access to broadband technologies for all its citizens, and to turn the country into a digital society that generates information, knowledge, and more socio-economic opportunities. In 2012 and 2013, the Ministry of Telecommunications and Information Society established the first set of policies in its National Broadband Plan, aimed at strengthening the digitalization of the country. The plan sought to bring Internet to the 24 provinces in the country, including the most remote areas, within four years. This effort was continued with the Organic Telecommunications Law (Ley Orgánica de Telecomunicaciones, or LOT), put forward in 2015. This law established concrete strategies to reduce the digital gap including universal access to all telecommunication services, the establishment of telecommunications infrastructure and the development and growth of ICT and technological leadership to enable new, accessible, and affordable services.

In Ecuador, the telecommunications sector is regulated in a hierarchical form. The Ministry of Telecommunications and Information Society, created in 2009, is the entity responsible for establishing policies and plans for the development of the sector and ICT, as well as for providing the security needed for the proper development of the information society. The Agency for Control and Regulation of Telecommunications (Agencia de Regulación y Control de las Telecomunicaciones, or ARCOTEL), is the body responsible for regulating, managing, and controlling all telecommunications and radio electric spectrum. It regulates infrastructure sharing, frequencies plan with services definition for 4G and 5G, infrastructure deployment, service provision and numeric portability, security and information protection, as well as user rights. ARCOTEL was created in an effort of unifying the responsibilities and competencies of other bodies such as CONATEL, the Superintendence of Telecommunications (Superintendencia de Telecomunicaciones, or SUPERTEL), the National Secretary of Telecommunications (Secretaría Nacional de Telecomunicaciones, or SENATEL), and the National Council for Radio and Television (Consejo Nacional de Radio y Televisión, or CONARTEL) (Rivera Zapata, Iglesias Rodríguez and García Zaballos, 2020).

Ecuador's success factors

In 2017, the government launched a set of public policies and the National Plan for Telecommunications with the aim of laying the ground for the country to become a regional leader in ICT by 2021.

The major objectives of this plan included increasing infrastructure deployment, improving access to ICT services, increasing outreach to all remote regions, and promoting the use of telecommunications in all productive sectors of the economy, especially small and medium enterprises.[11] This set of policies were followed by the Universal Service Plan launched in 2018, which focuses on increasing access and affordability of vulnerable populations, and by the Ecuador Digital initiative, launched in 2019.

Ecuador Digital is the action plan of the Ministry of Telecommunications and Information Society to digitalize all sectors of the economy by 2021, and to push forward the modernization of telecommunications infrastructure, in order to generate an economic, social, and political impact for the country. Currently, Ecuador is the eighth largest mobile market in the LAC region. Revenues coming from this sector represent about 2 percent of the country's GDP. This indicator, however, positions Ecuador behind other countries in the region, where revenues reach up to 5 percent (Ministry of Telecommunications and the Information Society of Ecuador, 2019).

The Ecuador Digital policy is aligned with the country's National Development Plan and was established within the framework of the National Agreement 2030, which aims at increasing the productivity and competitiveness of Ecuador's enterprises through digital innovation (Ministry of Telecommunications and the Information Society of Ecuador, n.d.b).

The overarching goals the government is pursuing for 2021 through the Ecuador Digital strategy are ambitious and include the following:

- Increasing the Internet penetration in schools from 32 to 68 percent.
- Increasing the number of homes with Internet access from 44 to 69 percent.
- Increasing the number of homes with computers from 40 to 62 percent.
- Increasing smartphone penetration from 33 to 66 percent.
- Increasing the usage of Internet in public and government institutions to 90.56 percent.

Through the Ecuador Digital strategy, the government also wants to improve the country's coverage and affordability indicators, thereby coming closer to regional leaders such as Chile. In terms of 4G, for example, Ecuador has currently 53 percent coverage, which is not much when compared to Chile's 99 percent. The goal is to achieve 80 percent coverage by 2021. In fixed Internet coverage, Ecuador's positioning comes closer to Chile's (44.37 percent versus 49.4 percent). The goal in this respect is to reach 59 percent by 2021.

[11] Interview with Paolo Cedeño, Undersecretary of Telecommunications and ICT, Government of Ecuador, September 2019.

With regards to affordability, the targets to be achieved are also significant. This is an area with tremendous opportunities and where Ecuador has some work to do. Currently, the cost of mobile devices is among the highest in the region; compared to other neighboring Andean countries, mobile phones in Ecuador are 43 percent more expensive than in Colombia and 13 percent more expensive than in Peru. Regarding fixed broadband Internet services, Ecuador ranks average among its LAC peers with US$2.61 per Megabit per month (Ministry of Telecommunications and the Information Society of Ecuador, 2019), following the top performer Chile, at US$1–US$1.3. In terms of mobile Internet, Ecuador is the second most expensive country in the region with an average of US$6.93 for 1 GB (Bolivia tops the ranks at US$8.51 for 1 GB).

Ecuador Digital is comprised of three programs (i.e., Connected Ecuador, Efficient and Cybersecure Ecuador, Innovative and Competitive Ecuador), aimed at tackling three core objectives: connectivity, government efficiency and cybersecurity, and country productivity. Connected Ecuador's major goal is to guarantee access to telecommunication services to 98 percent of the population by 2021. By increasing infrastructure deployment, the government aims at increasing 4G coverage from 50 to 80 percent by 2021, benefiting 4.8 million citizens and 254 municipalities (or parroquias). Tests for 5G started in August 2019 in Quito and Guayaquil and a total of 1450 Wi-Fi zones will be made available. The estimated annual investment for the deployment of new fixed and mobile infrastructure is of US$480 million for the time period between 2020 and 2022 (Ministry of Telecommunications and the Information Society of Ecuador, n.d.b). Other measures within this program include the following:

- Reductions to Internet prices by eliminating taxation to terminals.
- Reductions to international roaming tariffs.
- Implementation of emergency alert messaging system.
- GPS security.
- Digital television for the entire country by 2023.
- National tender for the 700 MHz, 2.5 GHz and 3.5 GHz bands. This is estimated to contribute to the creation of 27,200 new jobs (Ministry of Telecommunications and the Information Society of Ecuador, n.d.b).

At present, spectrum usage in Ecuador is at 26.9 percent ("Gobierno dará más espectro a cambio de más inversión", 2019), split in the following way:

- CNT: 36 percent.
- CLARO: 34 percent (US$660 million in assignment payments since 2008).
- MOVISTAR: 30 percent (US$370 million in assignment payments since 2008).

The objective is to increase spectrum usage from 26.9 to 65 percent by 2021 (using a similar methodology to the one that is being applied currently in Chile), and to provide access to 254 municipalities which currently do not have mobile services.

Regarding the program Efficient and Cybersecure Ecuador, its objective is to bring online about 80 percent of government processes by 2021, encouraging an open data policy. The government has estimated that online processes could represent savings to the government up to 95 percent and has the potential to limit corruption as it reduces bribing opportunities (thanks to the absence of in-person intermediaries in online transactions). In addition, through this program the government seeks to strengthen its national cybersecurity strategy and further protect its citizens' data.

Lastly, through Innovative and Competitive Ecuador, the government seeks to consolidate the National Agenda of Digital Transformation as a state policy by increasing ICT training, thus strengthening the economy. Some of the measures to achieve such purpose include the promotion of the "one tablet per child" project, benefitting 3.2 million children, fostering a culture of innovation and digital entrepreneurship. This is complemented by the launch of 877 information centers for ICT training as well as by the e-Commerce National Strategy in conjunction with the Ministry of Production, International Commerce, Investment and Fisheries.

The future: Challenges and opportunities

With Ecuador Digital, the country has many tools at hand to achieve its goals of granting universal coverage and turning the country into an information society. Nevertheless, the government should invest wisely and take actions to attract more foreign investment taking advantage of currently being one of the fastest growing economies in the region. Improving the regulatory environment, standardizing fees with the region, and developing a more stable legal environment that allows operators to raise the level of confidence in the country are just some of the suggested areas for Ecuador to focus on.

Some of the challenges the government and the Ecuador Digital strategy face in the coming years can be summarized as follows:

- Coordination between all actors, agencies and institutions involved in the implementation of Ecuador Digital's programs and plans.
- Development of an infrastructure map (passive and active) and coordination with private sector. This is meant to facilitate spectrum allocation, as well as infrastructure sharing and infrastructure deployment, especially in remote and "not investment attractive" areas.
- Revision and development of a secondary legal framework that promotes competition and investment, thereby complementing the LOT (Rivera Zapata, Iglesias Rodríguez and García Zaballos, 2020).

There are also some opportunities the government can capitalize on, such as the following:

- Strengthen backbone national networks to provide access to municipalities with little to no access to fixed or mobile Internet, as well as encouraging the development of community networks by dynamically allocating free spectrum.
- Subsidize underserved areas and vulnerable populations, as well as programs with prepaid tariffs or fragmented payment of devices.
- Create digital content for entrepreneurship, technology, and innovation, as well as ICT training.
- Use adequately a USF to support initiatives related to access, adoption, and usage.
- Develop a spectrum pricing policy that considers moderate reserve pricing, spectrum offering according to country needs, avoidance of out measured economic and financial conditions, and follows best practices on spectrum allocation.

The telecommunications sector in Ecuador has potential for improving all the above-mentioned indicators. Given that the density of services is below maturation stage, and that there is political will to enact the plans and programs set out in the Ecuador Digital strategy, a greater deployment of infrastructure can be achieved and as a result, a better digital ecosystem can be promoted which ultimately can reduce the digital divide.

Regional Case Study: Chile

Table 3.8. Country Profile: Chile

COUNTRY FACTS	ICT FACTS
Total land area: 756,700 km², of which 709,419 km² are rural areas	**Mobile cellular subscriptions per 100 people:** 134.4
Population: 18,730,000 habitants, of which 89.7 percent live in urban areas	**Mobile broadband subscriptions per 100 people:** 91.6
Population density: 25.2 per km²	**Fixed broadband Internet subscriptions per 100 people:** 17.4
GDP: US$298,230 billion	**Fiber Internet subscriptions per 100 people:** 2.2
GDP per Capita: US$15,922	**Individuals using the Internet (percentage of population):** 82.3 percent
Rank in Global Competitiveness Index: 33 (out of 141 economies). Chile is the most competitive country in Latin America.	**Internet affordability:** 8 percent for fixed broadband and 4 percent for mobile broadband.
School enrollment, primary (gross percentage): 101.4 percent	**Internet speed:** 20.38 Mbps mobile download; 90.47 Mbps Fixed Broadband download
School enrollment, secondary (gross percentage): 102 percent	**Rank in the ITU ICT Development Index:** 56 (out of 176 economies)
School enrollment, tertiary (gross percentage): 88.46 percent	**Overall rank in The Economist Inclusive Internet Index:** 13 (out of 100 countries)

Sources: IDB (2020); ITU (2017); Schwab and WEF (2019); Speedtest (2019); The Economist Intelligence Unit (2020); Trading Economics (2020a, 2020b); UNESCO Institute of Statistics (2021a); World Bank (n.d.a).

In the last decade, Chile has become one of the most connected countries in Latin America (EntrepeNerd 2017) and a technological leader in the region. Its prosperous economy and the overall state of its institutions, policies, and productivity make Chile one of the most competitive countries in the world and, so far, the most competitive in LAC (Schwab and WEF, 2019).

Although Chile enjoys a privileged position as a regional role model, it still has big targets to achieve especially if it wants to perform at the same levels of some of its OECD peers. Some of these goals relate to its technological capabilities which include enhancing its skills base, increasing the diffusion and use of ICT (especially in the public sector), and improving its innovation capability.

In Chile, the Ministry of Transport and Telecommunications (Ministerio de Transportes y Telecomunicaciones, or MTT), is the government's entity in charge of formulating all national policies for the sector. It works together with SUBTEL, an entity dependent of the Ministry which directs the implementation of telecommunications' policies and supervises the public and private companies of the telecommunications sector to ensure compliance with relevant laws, regulations, and standards. With the launch of the National Telecommunications Policy in the 1970s, the government provided the guidelines on telecommunication that govern the Ministry, services, institutions, and companies dependent or related to the state. In 1982, the General Law of Telecommunications allowed deregulation of the telecommunications sector, the entrance of new companies, and the promotion of competition. This law also established a complete separation between regulatory and operational functions. In March 2001, the provisions referring to the Telecommunications Development Fund (Fondo de Desarrollo de las Telecomunicaciones, or FDT), which is one of the first USF set in LAC (Townsend, 2019), were modified making it possible to provide direct subsidies from the state to the different telecommunications services that are installed in rural and urban areas with low incomes, especially regarding localities in isolated regions.

Chile's success factors

Previous administrations of the Chilean government also made significant efforts in bringing technology and telecommunications to the center stage of the country's public agenda. The general objectives of the current government (2018 to present) are to propel the country into being one of the most connected nations in the world, to reduce the digital divide by investing not only in high-speed broadband, but also in ICT skills, and to transform the nation into a true digital economy. Since the late 1990s, Chile has recognized the need to promote a National Digital Development policy as part of its strategy to boost economic growth and promote social inclusion. Some of the different initiatives promoted at national level in this matter are the Chile towards the Information Society, Digital Agenda 2004–2006, Digital Strategy 2007–2012, Agenda Digital Imagina Chile, and Chile's most current Digital Agenda 2020.

Chile's Digital Agenda 2020

Chile's Digital Agenda 2020 is a roadmap to move the country towards an inclusive and sustainable digital development. The role of the Digital Agenda is to take advantage of the full potential of technologies and expand it to each sector and across the territory. It also seeks to strengthen the sectorial agendas on connectivity (i.e., SUBTEL), productivity, innovation and growth (Ministry of the Economy), and electronic government and transparency (Ministry General Secretariat of the Presidency).

The Agenda is structured around five axes that establish strategic guidelines through specific lines of action which in turn materialize in 63 concrete measures (Government of Chile, 2020), namely:

- Axis 1. Digital rights: (i) regulatory framework for digital environment and (ii) fundamental rights for digital development (9 measures).
- Axis 2. Digital Connectivity: (i) augment quality digital access for everyone and (ii) improve conditions for a higher quality connectivity service (12 measures).
- Axis 3. Digital Government: (i) augment the use of the state's online services, (ii) support State sector policies through the use of technologies, (iii) strengthen an open and transparent state, and (iv) promote a more dynamic and innovative state (18 measures).
- Axis 4. Digital Economy: (i) digital transformation of enterprises, (ii) promote growth in ICT sector, and (iii) promote entrepreneurship and digital innovation (15 measures).
- Axis 5. Digital Competencies: (i) improvement of education quality through technology, and (ii) open job opportunities in the digital age(9 measures).

As of 2019, of the 63 measures, 24 have already been accomplished and 39 are still a work in progress. The axis that shows the biggest advancement is the one relating to Digital Connectivity, with 92 percent of its measures accomplished to date including the Digital Infrastructure Plan.

National Infrastructure Plan

Chile's National Infrastructure Plan (or Plan Nacional de Infraestructura 2014–2020) was created under the policies of Chile's Digital Agenda 2020 with the aim of accelerating digital inclusion and transforming the country into a digital hub for the southern hemisphere (SITEAL, 2020). Through public private partnerships, the plan seeks to supplement the efforts of the FDT to finance investment projects aimed at improving and increasing the capacity for data transmission at international level, boosting national fiber optic coverage, and reducing end users' costs (SITEAL, 2020). Some of the projects created within the subsidiary role of the state under the National Infrastructure Plan include the following:

- Connectivity for Education: This is a project which started in 2011 and within a year had more than 8,800 subsidized public and municipal schools with broadband access. This represented 96 percent of the country's school enrollment, equivalent to 3.1 million students.

- Todo Chile Comunicado: This project, launched in 2012, has been so far the largest initiative for digital connectivity in Chile. It gave mobile broadband 3G to 1,474 rural locations, benefiting more than 3 million Chileans. This project represents a total investment of US$45 million, where 65 percent of this amount (US$29 million) corresponds to subsidies/public investment, financed in equal parts by the FDT and the regions (SUBTEL, 2019b). To this is added the recent allocation of radio spectrum for 4G services, in the 2.6 GHz band, which includes mandatory mobile broadband service for another 543 isolated locations. In addition, 360 locations will be incorporated with subsidies to ongoing mobile phone and data expansion projects. All this will allow expanding the country's connectivity to 98 percent of the population (Secretaría Ejecutiva de Desarrollo Digital de Chile, 2013).

- FOA: It is a multimillion-dollar initiative launched in 2015 to benefit the areas of Aysén, Puerto Montt, and Punta Arenas. It is a project seeking to interconnect the Lakes region with the Magallanes and Antarctica through a 3,000 km cable deployment (one submarine and three terrestrial) with an investment close to US$78.5 million. Of these, the government intends to provide about US$74 million in subsidies coming from the FDT, with US$67.7 million intended for the submarine portion of the project, and US$6.2 million to the Magallanes portion (SUBTEL, 2019b). For the terrestrial portions of Aysén and the Lakes, which were awarded in May 2019, the intended subsidies are estimated to be US$5,549,230 and US$2,339,070 respectively (SUBTEL, 2019a). The project includes the installation and operation of physical infrastructure for telecommunications, whose main benefit corresponds to the provision of submarine optical channels and/or terrestrial optical channels, depending on the type of backbone of optical infrastructure. It intends to guarantee an open and non-discriminatory access as well as the provision of infrastructure capacity for the service and exclusive use of public bodies at a preferential rate. With this project, the deployment of open and non-discriminatory fiber optic infrastructure will be achieved in the southernmost part of the country, projecting to have the southernmost optical access point in the world, being only one step away from a future interconnection to the Antarctic continent. In July 2019, 60 percent of the works for the Magallanes portion were already completed and the start of operations is expected towards the end of the year (Carvajal Vega, 2019a, 2019b; Página 19, 2019; SUBTEL, 2017b).

- The National Optical Fiber project (Fibra óptica Nacional, or FON): It is based on backbone networks that originate in regional capitals and reach out to communal capitals (municipalities). The project contemplates the deployment of 10,000 km of fiber optic lines throughout the national territory, and it is structured around six macro zones that cover 13 of the 16 regions of the country, including 202 nodes located in 186 municipalities. For this project, the state granted a historical subsidy of US$120 million. The subsidy seeks to incentivize the industry to participate in bringing access to hard-to-reach areas. In October 2019, SUBTEL opened the contest to the public and awarded the project in early 2020 (Bnamericas, 2019c, 2019d; SUBTEL, 2018).

- Trans-Pacific Cable/Asia-South America Digital Gateway: This is a project undertaken by the government of Chile which aims at preparing the country to better face the digital revolution and facilitate the installation of data centers that turn Chile into a digital hub for Latin America. This unprecedented effort will be the first of its kind designed to digitally connect South America to the Asian continent through the deployment of a 24,000 km submarine fiber-optic cable with 4 potential landing points: Japan, Singapore, China, and South Korea. In September 2019, the Ministry of Transport and Telecommunications, through SUBTEL, awarded the tender for the economic, technical, and legal feasibility study of the submarine cable project to the consortium formed by the TMG and WFN Strategies. The US$3 million feasibility study will be financed by CAF, institution with which the Ministry of Transport signed a financing agreement in July 2019. The objective is to start deployment works by the second half of year 2021. The rough investment estimates for the project are between US$500–600 million (Xihuanet News, n.d.).

- Last mile investments: The government is also launching some last mile fiber optic investment projects in locations where there is precarious access. Among these investments, is the extension of the ChileGob Wi-Fi program, which includes government-run hotspots that provide free Wi-Fi in underserved areas with a total base investment for the evaluation model between US$3,000–3,500 million (SUBTEL, 2017a).

In addition to these programs and projects, the adjustment of normativity to encourage competition has also been essential to energize the telecommunications market in Chile. The country’s sector regulation is adapting to a scenario of technological convergence, which encourages the entry of new network and virtual operators, improves the quality of service, and drives price decline. Figures such as the infrastructure operator (introduced in 2010), have contributed to save long-term investment and operation costs in digital services. The essential elements in this policy have been the establishment of fixed and mobile number portability, terminal unlocking, change of fixed and mobile matching numbering, and the gradual elimination of the national long-distance fixed telephony. Other laws that have contributed to the modernization of the sector include: the Antennas Towers Law (that seeks to harmonize the development of the telecommunications industry with the community and its interests), the Network Neutrality Law (that enshrines the principle of network neutrality for consumers and users), the Law on Recovery and Continuity in Emergency Conditions in Telecommunications Networks, as well as the Infrastructure Operator Regulation Law, which allow the creation of a new layer of services (Secretaría Ejecutiva de Desarrollo Digital de Chile, 2013).

All these efforts emanated from Chile’s Digital Agenda 2020 and its National Infrastructure Plan are complemented by a new initiative launched by the current government under the name Digital Matrix Plan. Launched in 2018, the plan aims to accomplish the following:

- Guarantee minimum levels for speed and quality of Internet services.
- Reutilize/bury non-used national networks.
- Reduce tariffs for mobile telephony.
- Eliminate tariffs for international roaming with Argentina, Peru, and Brazil.
- Create a unique emergency number (as the 911 in the US).
- Deploy the FON and FOA projects.
- Create the digital roadmap for the Asian-South America Gateway.
- Increase the national investment in telecommunications by 30 percent.
- Implement 5G technology nationwide.

On the demand side, the Digital Matrix Plan aims to ensure that all public educational establishments have access to the Internet and are interconnected (Government of Chile, n.d.).

The future: Challenges and opportunities

There is no doubt that all the above-mentioned strategies, initiatives and programs have helped Chile come closer to its goals of reducing the digital divide and becoming a technology leader in LAC. Chile has made tremendous progress in terms of Internet penetration (going from 40.7 percent in 2012, to 82.3 percent today) (Government of Chile, n.d.), mobile cellular subscriptions (going from 129 percent in 2011 to more than 134 percent today), and free Wi-Fi access in municipalities (from 25 percent in 2012 to 99 percent in 2019 (Government of Chile, 2020).

However, there are still several challenges remaining with regard to affordability, the replacement of old technologies such as copper and hybrid, network accessibility in the last mile and remote areas, and an exponential increase in demand for high- speed networks in the next 20 years.[12]

With regard to the market forces, operators also face challenges as they seem to be working under a "competition model" assuming all market and technological risks, with investment maturity terms substantially less than 30 years (<7 years). The capital resources of the operators for infrastructure investments compete with other more profitable and shorter maturing investments, such as mobile telephony, cloud computing, content and applications, AI, and data centers.

[12] Currently, the country moves between 2 and 2.5 Tbps in national and international traffic (43 percent of which come from home connectivity needs); this traffic is expected to grow and reach the 81 TBps in the next 20 years, 60 percent of which will come from households (SUBTEL, 2018).

Furthermore, the multiple digital agendas (four in 12 years) have brought undoubtedly significant progress but also redundant efforts, which in some occasions have lacked continuity. At the municipal and regional level, implementation challenges also emerge. For instance, regional priorities do not necessarily go hand in hand with the central government's connectivity plans. Difficulties and delays in obtaining approval for the required infrastructure permits can take place when local authorities or communities have other priorities or different administrative processes (Government of Chile, 2013).[13]

The need for telecommunications infrastructure is constant, especially for a future 5G network, where there must be a sustained deployment of optical fiber, but also radio basis, antennas, towers and cells. The big ambitions stated in Chile's Digital Agenda must go hand in hand with an infrastructure deployment model that contemplates all the actors in the ecosystem and that is developed in close communication with the regions (Ramirez, 2019).

The results to be achieved in terms of connectivity with the FON, FOA, and Asian-South America Digital Gateway projects are not to be overlooked. They represent an opportunity for the country to increase capacity and prepare the road for the deployment of 5G. In October 2019, SUBTEL launched a public consultation on a proposal to grant telecommunications concession licenses to private companies interested in implementing 5G networks for use in their specific industries, including mining, ports, agribusiness, and transportation (Bnamericas, 2019d).

Accelerating the deployment of 5G networks will have multiple benefits to users in terms of speed and latency, which in turn will bring an increase in the demands of quality of service and rights of the consumers (SUBTEL, 2018). It will also require better coordination with the regions, Ministries, and other state actors. Chile currently has 28,000 mobile service towers that support various radiant elements. It is estimated that the development of 5G could double or triple that figure, since it will be necessary to increase the density of antennas by connecting them through more fiber optic and wireless transmission networks (in rural areas). This effort will involve huge investments of telecommunications operators and the evaluation of alternatives for passive infrastructure sharing. Because the implementation of 5G requires backhaul networks with extreme requirements in terms of capacity, latency, availability, energy and cost efficiency, infrastructure sharing is a viable alternative for incumbents and new entrants to offer 5G service. Therefore, successive allocations of spectrum for 5G bands will consider infrastructure sharing as compulsory, in cases where it is technically feasible to do so, and will adequately remunerate the investment effort of its deployment (SUBTEL, 2018).

[13] Interview with Daniel Urbina Toro, Advisor on Digital Strategy, SUBTEL, Government of Chile, October 2019.

In parallel, the requirement of quality of service indicators must be incorporated into the quality of service regulation that will be implemented as a result of the Law of Minimum Guaranteed Speed, which will ensure neutrality and transparency for the introduction of 5G. In addition, it is also necessary to ensure that all services and applications of 5G technology meet requirements regarding security, reliability, privacy, and user rights. Chile is expecting to start 5G deployments in 2021. A successful deployment of 5G (together with the accomplishment of the targets established by the above-mentioned government plans and projects) will help transform Chile's society into one of innovators and entrepreneurs, and help the country insert itself successfully into the fourth Industrial Revolution by enabling the development of new production models (SUBTEL, 2018).

4. Country Categorization Framework Results and Overall Recommendations to Governments

Strategies and Business Models for Improving Broadband Connectivity in Latin America and the Caribbean

Guidelines for the Planning, Investment, and Rollout of Broadband Networks

4. Country Categorization Framework Results and Overall Recommendations to Governments

This report introduces a country categorization framework that examines the current situation of broadband connectivity and regulatory environment for countries in LAC, as well as for Korea, Spain, and Estonia (role model case study countries). The framework, developed with the research support of the Center for Technology, Innovation, and Competition at the University of Pennsylvania (CTIC), plots countries using data collected in 2017 in a three-by-three matrix across two axes: the horizontal axis which indicates market concentration, and the vertical axis representing broadband penetration.

Country Categorization Framework Results for Fixed and Mobile Broadband

The competitiveness of a market is modeled using the Herfindahl-Hirschman Index (HHI), calculated by squaring the market share of each firm competing in a market and then summing the resulting numbers. The result is a measure of market concentration ranging from 0 to 10,000, with 0 representing perfect competition and 10,000 representing monopoly (see Table 4.1).[14] Broadband penetration is measured as the number of broadband Internet lines (for both fixed and mobile broadband) per 100 inhabitants (see Table 4.2). Both the HHI and broadband penetration data are taken from the IDB's Broadband Development Index.

[14] Given the relative concentration of broadband markets, the framework bases the HHI on the market shares of the four largest firms; in many cases there are only four or less providers.

Table 4.1. Horizontal Axis: Market Concentration

MARKET CONCENTRATION	DESCRIPTION
Highly concentrated	A market's concentration level is classified as high when the HHI is greater than 5,000. This cutoff represents the level of competition that would exist in a market consisting of two equally sized firms.
Moderately concentrated	A market's concentration level is classified as moderate when the HHI is between 3,333 and 5,000. The upper cutoff represents the level of competition that would exist in a market consisting of two equally sized firms. The lower cutoff represents the level of competition that would exist in a market consisting of three equally sized firms.
Unconcentrated	A market's concentration level is classified as low when the HHI is below 3,333. This cutoff represents the level of competition that would exist in a market consisting of three equally sized firms.

Source: Authors' elaboration.

Table 4.2. Vertical Axis: Broadband Penetration

STAGE	DESCRIPTION
Low penetration	Penetration for fixed broadband is classified as low when the number of fixed broadband lines per 100 inhabitants falls between 0 and 10. Penetration for mobile broadband is classified as low when the number of mobile broadband lines per 100 inhabitants falls between 0 and 40.
Moderate penetration	Penetration for fixed broadband is classified as moderate when the number of fixed lines per 100 inhabitants falls between 10 and 25. Penetration for mobile broadband is classified as moderate when the number of mobile broadband lines per 100 inhabitants falls between 40 and 70.
High penetration	Penetration for fixed broadband is classified as high when the number of fixed broadband lines per 100 in habitants exceeds 25. Penetration for mobile broadband is classified as high when the number of fixed broadband lines per 100 inhabitants exceeds 70.

Source: Authors' elaboration.
Note: The cutoffs for high, moderate, and low broadband penetration follow the thresholds used in other parts of the literature.

Tables 4.3, 4.4 and 4.5, and Figures 4.1 and 4.2 show the results of the country categorization framework developed for this report. Table 4.3 shows the 26 LAC countries studied, alphabetically listed (as well as Estonia, Korea, and Spain), with their score in both fixed and mobile broadband connectivity. The key indicators in this table include the following:

RG-COBF = Market concentration for fixed broadband:

- <3,333 Unconcentrated
- 3,333 – 5,000 Moderately concentrated
- >5,000 Highly concentrated

IN-LBAF = Fixed broadband penetration:

- >25 High penetration
- 10–25 Medium penetration
- <10 Low penetration

RG-COBM = Market concentration for mobile broadband:

- <3,333 Unconcentrated
- 3,333– 5,000 Moderately concentrated
- >5,000 Highly concentrated

IN-LBAM = Mobile broadband penetration:

- >25 High penetration – Fixed broadband
- 10–25 Medium penetration – Fixed broadband
- <10 Low penetration – Fixed broadband

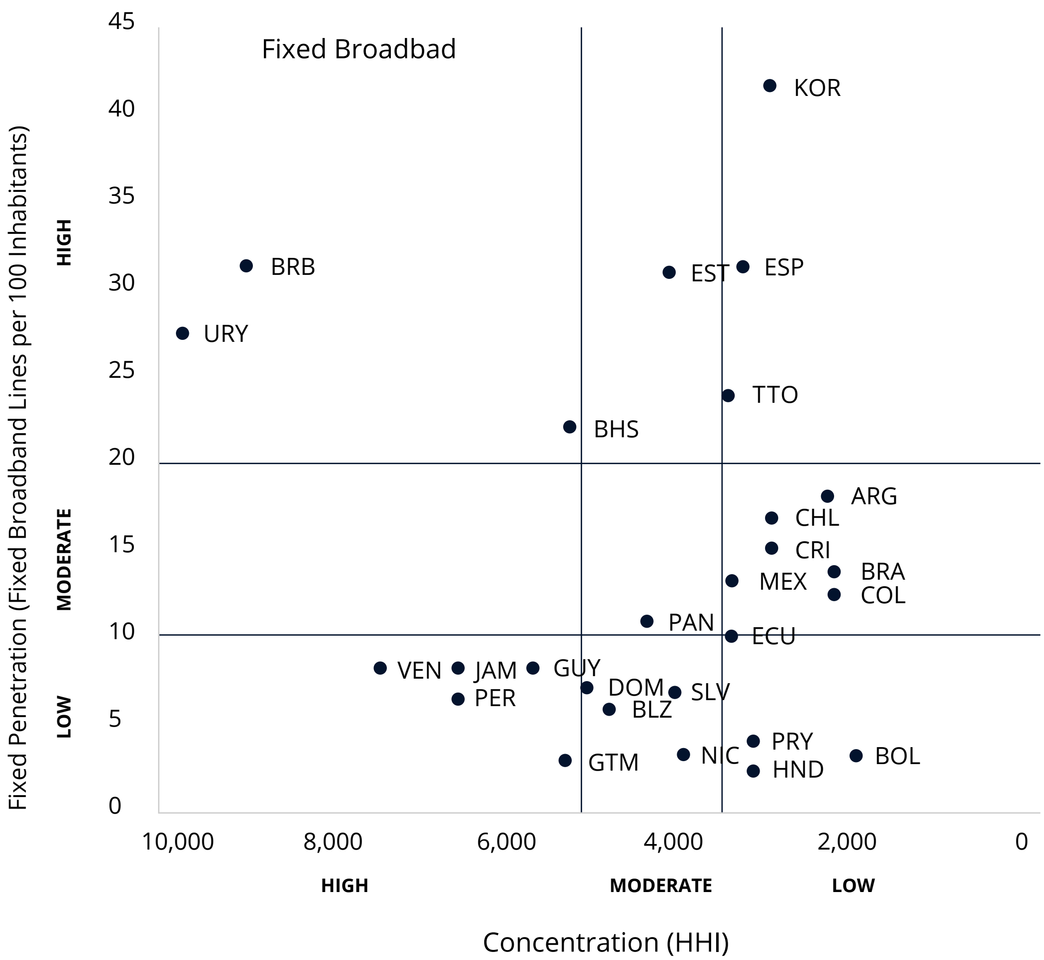
Table 4.3. Country Categorization Framework Results

COUNTRY	INITIALS	RG-COBF	IN-LBAF	RG-COBM	IN-LBAM
Argentina	ARG	2,355	18	3,248	67
Bahamas	BHS	5,304	22	10,000	82
Barbados	BRB	9,026	31	5,001	51
Belize	BLZ	4,822	6	5,221	30
Bolivia	BOL	2,106	3	3,491	76
Brazil	BRA	2,227	14	2,495	90
Chile	CHL	2,959	17	3,214	88
Colombia	COL	2,234	13	3,326	49
Costa Rica	CRI	2,927	15	4,187	117
Ecuador	ECU	3,469	10	4,029	53
El Salvador	SLV	4,301	7	2,681	56
Guatemala	GTM	5,337	3	3,864	10
Guyana	GUY	5,825	8	5,085	26
Haiti	HTI	-	-	-	-
Honduras	HND	3,264	3	5,154	24
Jamaica	JAM	6,670	8	5,784	49
Mexico	MEX	3,410	13	4,850	64
Nicaragua	NIC	4,031	3	4,808	30
Panama	PAN	4,400	11	3,022	61
Paraguay	PRY	3,277	4	3,644	48
Peru	PER	6,603	7	3,255	64
Dominican Republic	DOM	5,153	7	4,587	56
Suriname	SUR	-	-	5,003	76
Trinidad y Tobago	TTO	3,464	24	5,151	46
Uruguay	URY	9,802	27	4,001	112
Venezuela	VEN	6,973	8	3,686	50
Korea	KOR	2,980	42	3,766	113
Estonia	EST	4,152	31	3,417	133
Spain	ESP	3,324	31	3,022	96

Source: Authors' elaboration (drawing on data taken from the IDBA's 2018 Annual Report).
Note: See Annexes 1-4 for a more detailed breakout on the country rankings.

For better visualization of the data and the place each country holds according to market concentration and broadband penetration, the Country Categorization Framework results presented on Table 4.3 have been plotted in two Figures. Figure 4.1 shows the results for fixed broadband, and Figure 4.2 shows the results for mobile broadband. In both cases, broadband penetration and market concentration were considered.

Figure 4.1. Country Categorization Framework Results for Fixed Broadband



Source: Authors' elaboration.

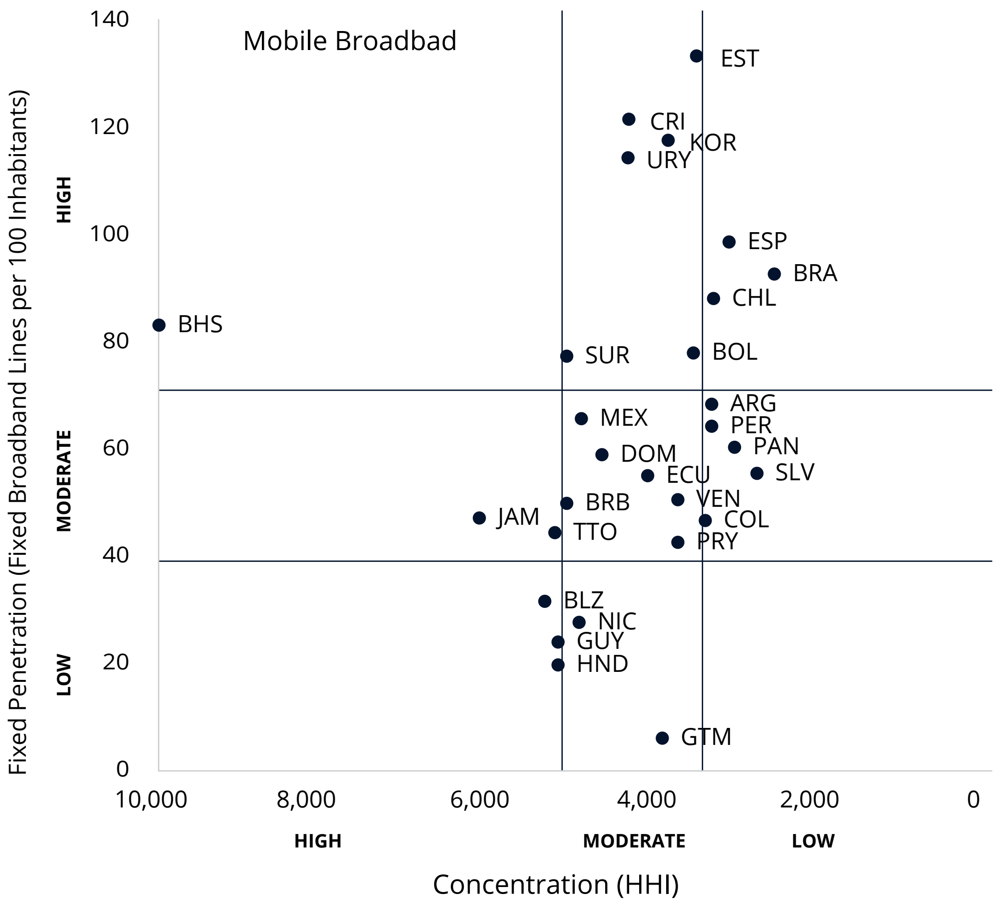
Table 4.4. Fixed Broadband: Penetration versus Market Concentration

Horizontal axis Market concentration / Vertical axis Fixed broadband penetration	HIGHLY CONCENTRATED	MODERATELY CONCENTRATED	UNCONCENTRATED
HIGH	**Barbados** **Uruguay**	**Estonia** **Spain**	**Korea**
MEDIUM	**Bahamas**	**Ecuador** **Mexico** **Panama** **Trinidad & Tobago**	**Argentina** **Brazil** **Chile** **Colombia** **Costa Rica**
LOW	**Dominican Republic** **Guatemala** **Guyana** **Jamaica** **Peru** **Venezuela**	**Belize** **Nicaragua** **Salvador**	**Bolivia** **Honduras** **Paraguay**

Source: Authors' elaboration.

For fixed broadband, the country categorization results show that the best performers in the LAC region are Argentina, Chile, Costa Rica, Brazil, and Colombia (see Table 4.4). These five countries have an unconcentrated market and have achieved a medium level of fixed broadband penetration. There is no country in the region yet that achieves the top marks of countries like Korea with unconcentrated markets and high levels of fixed broadband penetration. Bolivia, Honduras, and Paraguay, although having a liberalized market, still fall behind their regional peers in terms of fixed broadband penetration. Barbados and Uruguay have achieved high penetration of broadband despite a highly concentrated market.

Figure 4.2. Country Categorization Framework Results for Mobile Broadband



Source: Authors' elaboration.

Table 4.5. Mobile Broadband: Penetration versus Market Concentration

Horizontal axis: Market concentration / Vertical axis: Mobile broadband penetration	HIGHLY CONCENTRATED	MODERATELY CONCENTRATED	UNCONCENTRATED
HIGH	Bahamas Suriname	Estonia Costa Rica Korea Bolivia Uruguay	Spain Brazil Chile
MEDIUM	Barbados Jamaica Trinidad & Tobago	Colombia Dominican Republic Ecuador Mexico Paraguay Venezuela	Argentina Panama Peru Salvador
LOW	Belize Guyana Honduras	Nicaragua Guatemala	

Source: Authors' elaboration, based on data from IDB (2020).

For mobile broadband, the country categorization results show that the best performers in the LAC region are Brazil, Chile, Costa Rica, Uruguay, and Bolivia (see Table 4.5). These countries have unconcentrated and moderately concentrated markets with high penetration rates for mobile broadband. Bahamas and Suriname have high penetration rates for mobile broadband despite having highly concentrated markets.

Analysis of the results

Across both fixed and mobile broadband of the five case study countries, Korea, Spain, and Estonia appear to be unconcentrated/moderately concentrated, but have high levels of broadband penetration. Ecuador and Chile are both moderately concentrated/unconcentrated and appear to exhibit medium/low levels of fixed broadband penetration. Ecuador is similarly characterized for mobile broadband, but while Chile remains moderately concentrated/unconcentrated, it has moderate/high levels of mobile broadband penetration.

The analysis presented in the country categorization framework identifies certain outliers. For example, Figures 4.1 and 4.2 identify two countries that have achieved high fixed broadband penetration despite having highly concentrated fixed broadband industries: Uruguay and Barbados. The fixed broadband provider in Uruguay is a government-owned monopoly that has chosen to keep its prices at a moderate level, that is, lower than what the market would bear. Fixed broadband in Barbados is provided by the privately-owned Cable & Wireless Communications, under the Flow brand name. Neither of these countries offer a policy solution for the others based on international best practices. They may be able to achieve higher penetration by further liberalizing their markets.

For mobile broadband, the clear outlier is the Bahamas, which has achieved high penetration despite having a highly concentrated industry by charging moderate prices that are below what a monopoly would ordinarily be able to charge. Mobile broadband in the Bahamas is provided by the Bahamas Telecommunications Company (BTC), which was a government-owned monopoly until 2011, when it sold a 51 percent equity stake to Cable & Wireless Communications. This lasted until 2014, when Cable & Wireless Communications transferred 2 percent of the company back to the government.

For the majority of the LAC countries studied in this report, there is still significant work to do in order to achieve universal broadband connectivity. Though there has been strong progress in mobile broadband penetration, increasing fixed broadband penetration remains a big challenge for the region, especially as this will require shifting toward more liberalized markets and a review of current policy frameworks and regulations to attract the capital investments that will be required. This will be crucial if countries are to benefit from the technological advancements of the new decade given the capacity, backhaul, and latency requirements that these technologies will require.

Building a Connectivity Network for the Future

The new decade that has just begun will bring significant technological advancements which are poised to revolutionize entire industries, businesses, and the way we address world challenges. Smart economies, smarter cities, AI with human collaboration, IoT, the Internet of everything (IoE), and high bandwidth brain-computer interfaces will settle in, thus creating pressures to governments for stronger, faster, and more secure platforms to run on.

As middle-income populations all over the world continue to rise—a phenomenon partly due to the convergence of high-bandwidth and low-cost communications—, so will the digitization of everyday goods and services. These will in turn become even more available on mobile devices to middle-income and low-income populations.

Rises in capital flows (i.e., seed money, venture capital, and sovereign wealth funds) will continue to impact innovation by financing entrepreneurial ideas, especially in the fields of ICT. According to the Singularity Hub, a science and tech media website owned by the Singularity University, already US$300 billion in crowd funding is anticipated by 2025, thus enhancing capital access opportunities to entrepreneurs worldwide (Diamandis, 2020).

Licensed and unlicensed 5G, along with global satellite networks, will enable ubiquitous and fast connectivity for everyone and everything. Today's connectivity is bringing online an additional three billion individuals, driving tens of trillions of US dollars into the global economy (Diamandis, 2020). 5G networks (100 Mbps to 10 Gbps connection speed), augmented reality (AR), and hardware advancements will also enable the arrival of the Web 3.0, as well as the widespread use of intelligent devices and machines.

IoT will continue growing and IoE will increase the use of ultramodern electronic sensors to help measure, listen, and visualize every environment at any time. Global imaging satellites, more advanced drone technology, and vast data networks will help humanity increase the current capacity for unlimited and ubiquitous knowledge.

AI-human collaboration will continue to expand, impacting significantly areas such as healthcare and medicine, helping unleash new drugs and assist in clinical trials. According to technologist and futurist Ray Kurzweil, AI will reach human-level performance by 2030 (Reedy, 2017). AI algorithms and machine-learning tools will be made open source and available on the cloud. This trend will be driven by the convergence of global high-bandwidth connectivity, neural networks, and cloud computing. Furthermore, the rise of artificial intelligence as a service platform (AIaaS) will enable humans to partner with AI, leading to its entrenchment in everyday business operations (Diamandis, 2020).

All these trends show that affordable, ubiquitous connectivity, and high bandwidth (e.g., > 100 Mbps) are important goals to be taken into consideration by any government. The networks that are used in the world today are built on voice and mobile broadband services, as well as on available, reliable, and in some instances affordable technologies that must allow multipurpose functions such as human-to-human, human-to-machine, and machine-to-machine communications. Future network platforms should provide specific connectivity performances to guarantee all these requirements. Latency, for example, is a critical issue where a controller or complex AI must take decisions and actions in real time (Ekudden, 2019). Complex architectures in cyber-physical systems require adaptive network platforms and network slicing to enable satisfying heterogeneous connectivity requirements and streamlined connections on the same network, for any indoor or outdoor scenarios (Ekudden, 2019).

Thus, future applications require stronger networks with higher processing capabilities, lower latency, and increased robustness and security. To satisfy these needs, future network platforms must be designed to be agile, versatile, and instantaneously meet any application requirements. They should be able to handle huge to scarce amounts of both open and sensitive data at ultrafast processing speeds that enable them to meet specific up and downlink transmission demands. Key features of future 5G networks also include improved indoor coverage, maximal energy efficiency, and fiber-like performance. Future wireless access networks will consist of a wide range of different types of nodes jointly providing wireless access coverage. Devices will in many cases have simultaneous connectivity to multiple network nodes, including different access technologies, for enhanced performance and reliability. Wireless technology will also be used for the connectivity between the network nodes, as a complement to fiber-based connectivity (Ekudden, 2019).

As all these technological trends consolidate the need for safer and more secure yet agile networks, security assurance procedures play an important role verifying the security of the network platform. Network architectures based on cloud technologies and virtualization might pose some challenges and require continuous compliance verification. In coming years, trends will grow in relevance that will include encryption, trust-enhancing regulatory requirements, and assurance technologies to protect network platforms (Ekudden, 2019).

The future network must reach everyone, and it must have the capacity to carry everything. However, future network platforms will also have to be upgraded in a variety of ways to be able to deliver new advanced services. They must be able to instantly meet any application need at any time, provide ubiquitous radio access, security assurance, and an evolution into zero-touch networks (those capable of self-management and controlled by business intents). To deliver the low latency made possible by 5G and new fiber networks and to provide real-time services, edge computing will be required to store and process information closer to the end user. Moreover, connectivity will need to be embedded into more physical devices, requiring the network to connect them together and provide intelligence, while end users will have an increasing array of devices for interacting with the networks.

The futuristic ideas and outlook introduced in this chapter intend to motivate governments to seriously think about the status of their broadband strategies and whether their current networks are ready to take on the technological and consumer driven challenges that will emerge in the coming years. The remaining sections of this report will focus on outlining recommendations to LAC governments on what to do next to achieve the ultimate goal of providing their citizens with more, better, faster, and affordable broadband connectivity. The recommendations include three major groups: general market sector reform recommendations, recommendations for increasing Internet penetration in middle mile, backbone, and last mile networks, and lastly, recommendations for addressing the demand side of the problem.

Overall Recommendations to Governments

For both fixed and mobile broadband, most of the LAC countries analyzed navigate between moderately and highly concentrated types of market with medium to low penetration levels. This section provides general recommendations for policy making to address general market/sector reforms to create a more appropriate environment to attract private sector investment. The recommendations are a result of the case study analyses, research, and several expert interviews. They are tailored according to the type of market a country finds itself in, namely highly concentrated, moderately concentrated, or unconcentrated market.

Recommendations on general market sector reform

Regardless of the type of market, governments must have a coherent vision, political will, and strong leadership when developing their broadband strategies and digital agendas. This is particularly relevant to face common public policy implementation barriers such as lack of interinstitutional coordination, as well as overlapping mandates and initiatives which lead to inefficient use of public funds and efforts. Furthermore, a coherent public policy strategic vision facilitates predictable and successful implementation of specific actions beyond electoral cycle horizons, which in its turn provides the certainty and stability desired by private sector market stakeholders and investors. A recent ITU study (2019c) highlights that regulatory and policy frameworks have a consistent impact on the development of the digital ecosystem, regardless of the country's level of development. Government intervention should be based on clear policy objectives and an open mindset toward developing a cooperative and trustworthy relationship with the private sector. Some of the key recommendations (Kende, 2019) for solid and inclusive national broadband strategy plans include the following:

- Having specific and attainable targets: Measurable and realistic targets help governments align resources and concentrate efforts. Direct targets such as deployment (e.g., number of households with new FTTH network) are important, but other indirect targets (e.g., adoption levels, broadband speeds, training, usage in SME, etc.) are also critical for ensuring that broadband is being used.

- Independent agency: To guarantee independence and accountability, and to enforce implementation it is always useful to designate one agency as the lead. In some cases, the agency already exists in the form of the regulator, and in other instances a new agency needs to be created as the lead.

- Funding: National broadband strategies and plans must be funded through several sources, such as the Universal Service Obligation (USO) funds, general tax revenues, or from collaboration with the private sector through Multi-Sector/PPP.

- Open access: Infrastructure should be made available to other operators. If it is a government-funded infrastructure, it should be directly available, whereas if it is funded through PPP with a private partner involved, then schemes to make it indirectly available should be considered. The wholesale cost of accessing the network should be based on costs, that way competitors can engage openly with the owner of the network.

General market sector reform recommendations for countries with a highly concentrated market

In countries with a highly concentrated market (highlighted in red in Tables 4.4 and 4.5), that is, with a monopolistic environment or with concentration on two equally sized firms, the main effort needs to be toward opening the market and spurring competition. Generally, it includes three stages:

- Liberalize the market to allow competition: Opening telecommunication markets enables competitors to enter and compete with the incumbent in fixed markets, or to develop a mobile competitor. Entry should be enabled at all levels of the access infrastructure value chain, so that competitors can build their own infrastructure and compete with the incumbent. As a result, retail prices should be set through market competition, rather than regulation. Where entry may not be feasible, wholesale access to those parts of the incumbent's network may be required, at regulated rates. These rates are ideally set by an independent regulator, as described below, to avoid favoring the incumbent, which is further promoted by separating the incumbent from the government.

- Corporatize the incumbent and possibly privatize it (to allow investment): If the incumbent is part of a Ministry, it should be corporatized. This way, it will no longer directly be part of the government, but rather a separate corporate entity, where private investment can flow in. Where the government owns the incumbent (or the majority of it), there may be concerns that regulation will favor the incumbent. It may also be difficult for the incumbent to reform its structure if it is still owned by the government.

- Develop an independent regulator to create a level playing field between the incumbent and competitors: A regulator can neutrally act to open markets, regulate retail prices where there is no competition, and allow for wholesale access to facilitate entry.

This can be challenging if the government owns the incumbent, as it might give the perception of favoritism, which in turn can impact investment. Independent regulators not only can act as neutral agents between the incumbent and new entrants, but also provide stability when there is a change in government leadership (Kende, 2019).

General market sector reform recommendations for countries with a moderately concentrated market

In countries with a moderately concentrated market (highlighted in orange in Tables 4.4 and 4.5), that is, where there are at most three equally sized firms dominating the market, the main effort needs to be towards further strengthening competition. This can be made possible by the following:

- Making entry feasible with license conditions, low costs, and transparent and straightforward procedures. It is not enough to liberalize markets if it is difficult to get a license. Rather than limiting the number, it is recommended to have broad unified licenses at equitable fees to enable operators to provide a wide range of services at fair prices. Shorter “wait periods” for licenses also help businesses deploy on time and within budget (Kende, 2019).

- Where competition is not feasible, regulating retail prices and allow cost-based access to incumbent’s facilities. Wholesale access to the incumbent’s network can increase competition. For instance, certain sectors of network infrastructure may not prove to be efficient for competitors to build their own infrastructure, because the costs are too high and/or demand is too low. This could relate to parts of the local access network, backhaul, backbone, submarine cable capacity, or landing stations. In these areas, wholesale access to the existing infrastructure should be enabled at cost-based prices. The regulator must have transparent and non-discriminatory procedures for granting access, decisions must be taken within a set time period, and the costs must be transparent and non-discriminatory. This may increase competition and enable retail price regulations to be relaxed or removed.

- Introducing timely and effective ex post competition controls to make sure there are no price squeezes or other anti-competitive actions. To ensure fairness, the incumbent should effectively account for the wholesale prices that it charges others when it sets retail prices. This helps to ensure that there is not a ‘price squeeze’ in which there is too little gap between the retail price and wholesale rates. The result is that competitors cannot compete because the profit margin is too low to cover their costs, but of course the incumbent is effectively paying itself the wholesale rate and is not impacted by the price squeeze.

The regulator must test for the price squeeze, and when it occurs appropriately adjust the wholesale rate and/or retail rates. The competition authority of a country may also timely and effectively examine the price squeeze or other anti-competitive actions for ex post abuse of market power on the part of the incumbent.

General market sector reform recommendations for countries with an unconcentrated market

In countries where there is already an unconcentrated market with many competitors (highlighted in green in Tables 4.4 and 4.5), the efforts should be oriented towards maintaining an open and fair competitive environment:

- Remove ex ante competition regulations (retail prices and cost-based access) where there is competition. As competition increases, ex ante regulations may create obstacles by not allowing operators to compete on a fair playing field and may even keep prices from continuing to fall. One sign that regulations are no longer needed is when retail or wholesale prices begin to fall below the regulated rate. That is particularly true when the incumbent begins to undercut those prices, suggesting that it is under competitive pressure in the retail market, and beginning to compete strongly in providing wholesale access. The regulator can remove those regulations, but still maintain reporting requirements, for instance, to ensure that competition remains strong.

- Ensure timely and effective ex post competition regulation to keep competition, including merger reviews. In addition to keeping a minimal set of ex ante competition regulations, it is also important to maintain ex post competition regulation, as traditionally applied to all sectors of an economy. This can ensure that companies do not collude to keep prices high, that they do not leverage market power in another market into the telecom markets, and that they do not foreclose competition, for instance by blocking voice over IP calls. In addition, it is important to review relevant mergers to ensure that market power is not recreated through acquisitions.

Recommendations for increasing access in middle mile and backbone networks

The Internet generates significant amount of traffic, which must be carried by others from international access points through the country to last mile networks. It is important that there are networks with sufficient capacity to carry this traffic, particularly in remote and rural areas. It should also be ensured that there are sufficient competing networks.

Several reasons justify this. First, competing networks will lower wholesale prices, enabling other companies without infrastructure to compete, and these lower prices will also be passed on to retail prices, making the Internet more affordable. In addition, competing networks will ensure redundancy and resilience, so that if one network is cut, there are other networks that can carry traffic while it is being repaired. A key part of deploying networks is the access to ROW—the permission to deploy networks, in cities but also across the country. The following list summarizes key recommendations for increasing access in middle mile and backbone networks.

- Ensure that all network industries—roads, railroads, electrical—can make their ROW available to telecommunication operators to build networks. Countries typically have in place: a road network, an electric network, water utilities, sewer systems, and railroads. These networks have ROW. Allowing telecommunication operators access to those ROW can significantly speed up the process of deploying a network. One or several operators can dig fiber next to the highway or use the electric transmission network poles to deploy aerial fiber. Two aspects are important to consider. Ideally, when telecom infrastructure is deployed, it is important to ensure that it is shared among operators to lower costs and disruption to the network. For instance, fiber ducts can be installed next to roads so that multiple operators can put their own fibers through without having to dig up the roads again ("dig once policy", as explained in Chapter 3). Likewise, when new networks are built (e.g., electric transmission, railroad, roads, etc.) telecommunication operators should be notified so that they can deploy networks at the same time, further lowering the cost of deployment.

- If any network industries have their own fiber networks, it is important to promote their participation in the market by making it available on a wholesale level or on a retail level. Electric utilities and railroads often install their own fiber networks on their ROW for operations and signaling. This infrastructure can be efficiently used by telecommunication operators for their own networks on a wholesale level, and the utilities could also be licensed in their own right as telecommunication operators compete in markets themselves. Either way, these existing networks must be fully utilized and encouraged to expand in a cost-efficient way.

- Streamline ROW permits and encourage infrastructure sharing to lower the cost of deploying infrastructure. Municipalities and jurisdictions typically have their own procedures, fees, and deadlines. Even where there are established national procedures (e.g., permission to deploy cellular towers), these could be long, uncertain, and expensive. Some recommendations to address the issue of diverse municipalities' procedures include the development of standardized application forms, common deadlines, and timetables, as well as using cost-based methodologies across all municipalities.

Streamlined processes (coming from the government) and regulations to facilitate access to ROW might also help reduce uncertainty in regard to access to land and government permissions. Likewise, procedures for granting access must be transparent and non-discriminatory. Where there are existing facilities that could be used, owners must meet reasonable requests for access at fair prices (Kende, 2019).

Recommendations for spectrum and accessibility in the last mile networks

Last mile access is critical to bring users online, and mobile access is an indispensable part of the last mile in all countries. Mobile access is in many situations the only means to go online in some geographic areas. Therefore, spectrum policy is an important element of online access. All the recommendations in this and the preceding subsection are meant to lower the commercial cost of deploying networks. Where deployment is still unlikely, it may be important for the government to use its own funds to complete the network.

- Ensure that sufficient spectrum is available for operators at a reasonable cost, in spectrum bands that are internationally recognized and have available equipment and devices. Spectrum is essential to the availability and quality of all services, especially for mobile broadband. Transparent and easy to understand procedures are essential for making spectrum available. National allocations should be easy for businesses to understand and in recognized bands for equipment and devices; spectrum should be allocated to allow sufficient bandwidth without congestion. Spectrum must also be made available for trials and new services, entrants, and new mobile generations. Flexibility (e.g., allowing that existing spectrum allocations are used for upgraded networks), spectrum sharing, and secondary use are some examples of emerging trends in spectrum management that allow for increased competition and a more efficient use of the spectrum (Kende, 2019).

- Coverage and speed requirements can be put into the spectrum licenses, which may lower the returns from the spectrum, but could result in efficient coverage of new areas. Spectrum is typically auctioned to operators, to ensure that it is assigned efficiently, and to help raise revenues for the government. Putting in coverage requirements in the spectrum licenses—targeting high cost/low demand areas without coverage—will lower the willingness to pay for the spectrum. However, the mobile operators are well placed to deploy networks and thus the tradeoff between government revenues and coverage should be carefully weighed. That is particularly true if the government would otherwise fund deployment of networks in those areas, as the mobile operators are likely to be able to do it at a lower cost.

- Encourage tower sharing to save on the cost of deployment. In addition to sharing deployment of middle mile and backhaul, sharing mobile towers is very efficient. Often third-party companies will own and operate the towers on behalf of the mobile operators to ensure efficiency. The government can facilitate this process by reducing or removing licensing requirements for stakeholders building towers. They can encourage and even require tower sharing on government land in dense urban areas to avoid overbuilding, and when government funds are used for deployment.

- USF can also be used to expand coverage and should make infrastructure available to all operators. As a last resort, where commercial deployment is unlikely under all the recommendations above, the government can fund deployment, typically through a PPP or a competitive tender to ensure commercial participation. In these cases, the network deployed should either be shared among the operators or made available to operators at cost-based rates to ensure competition in these areas.

- Improve coordination between central and federal government agencies and other actors for the efficient deployment of broadband networks. Establish clear guidelines on who grants permits and licenses (regular and ancillary). Central and federal governments need to align their priorities. They will need to reduce ineffective paperwork, review landscape of digital initiatives to avoid duplicity, and review current procedures to guarantee a more efficient execution and deployment of broadband networks.15

- Introduce mapping tools and funding network-mapping initiatives. This will help point out the locations of significant pockets of population densities without access to broadband networks.16

- Allocate money to finance initiatives for community networks and rural connectivity. Because small communities typically do not have enough assets to be placed as collateral when applying for bank loans, governments should provide financial aid to local and homegrown initiatives as well as to rural banks funding last mile connectivity projects. Governments should also do more in regard to financial literacy training programs for rural communities, so they have ways of running sustainable businesses for connectivity.17

[15] Interview with Ricardo Martínez Garza, Former Advisor to the Undersecretary of Communications, Secretary of Communications and Transport, Government of México, October 2019.

[16] Interview with John Garrity, Chief Technical Advisor, UNDP, August 2019.

[17] Interview with Jane Coffin, Senior Vice President, Internet Growth, Internet Society, September 2019.

Recommendations for the demand side

As important as dealing with the supply side of the issue, specific measures and guidelines must be followed and put in place by governments to make sure their populations have access and can truly benefit from high-speed broadband networks. Given the widespread deployment of mobile broadband, it is typically the case that not all citizens who have access to mobile broadband actually use it, highlighting that there may be some barriers on the demand side, which can include affordability, skills, and the relevance of available content. Some of the recommendations regarding the demand side of the problem include the following:

- Encourage digital and literacy skills education throughout the educational system. This will help and motivate citizens to actively access and use technology. Children should be learning basic digital skills in schools; they can also encourage their parents to go online and help them learn. In addition, at common access points such as Internet cafes, facilitators can be made available to help people go online. Likewise, job training should be encouraged to make sure that current workers are 'up skilled' to be able to compete on the job market. Given the rapid changes in technology, digital skills training should be seen as lifelong, rather than one-time training.

- Find local champions to address reluctance to change behaviors and help embrace technology and the Internet in rural communities. Use teachers and young technologically savvy people to train the elderly and help dissipate fears and lack of ICT knowledge.

- Promote content that is relevant to local residents. Local companies may be best placed to identify gaps in the market for new content and services that will be attractive to users. Thus, the government can help by stimulating local ICT startups and businesses to meet the gaps. This will also help to create local jobs and revenues. In parallel, e-government services may be developed for a range of benefits. For example, the creation of these services generates demand for more online services. It can also help governments efficiently reach and interact with citizens. In addition, it can provide local jobs to develop the services and demand for data centers to host the services.

- Attract international platforms to be hosted locally. Facebook, Snapchat, and other platforms are international companies, but by enabling local connections for social, employment, or government purposes, they can be considered among the locally relevant content that can increase demand. Any content regulations should be made clear and transparent, and intermediaries should not have liability for what other people upload to the platform. Instead, they should be required to remove the content if it violates local content regulations or copyright.

- Remove high taxes on devices and services to increase affordability and facilitate adoption. According to the ITU (2019c) report The economic contribution of broadband digitization and ICT regulation, a 10 percent drop in prices will boost adoption in the Americas by more than 3 percent in fixed broadband and by more than 0.9 percent in mobile broadband. Competition will of course help lower prices, but taxes will put a floor on how low prices can go—in particular, sector specific taxes on devices, consumers, and companies can significantly increase prices and should be examined and reformed.

- Ensure trust and security in the use of ICT through legislation that protect users. This constitutes a key enabler to facilitate active usage of ICT-based services, in particular for those services for which personal and other sensitive data (e.g., biometrics, financial, payment details) needs to be entered.

- Promote e-commerce, e-government, and a digital economy to contribute to mainstreaming ICT-based services within and between private sector and civil society. This would expand the benefits of digital technologies beyond public service delivery and productive sectors, which traditionally were amongst their main heavy users.

Increasing broadband connectivity is of paramount importance for LAC to overcome developmental challenges. Market liberalization and government intervention based on clear objectives and a constructive and transparent collaboration with the private sector is essential for a healthy development of national broadband markets. Regulatory changes must go together with upgrades in infrastructure and measures to address the demand side of the problem. A holistic, inclusive, and innovative approach is urgently needed to ensure that all the benefits broadband brings also reach the most vulnerable and marginalized populations.

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Annexes

Annex 1. Country Categorization Framework: Ranking of the Market Concentration for Fixed Broadband

<3,333	**Unconcentrated**
3,333 - 5,000	**Moderately concentrated**
>5,000	**Highly concentrated**

INITIALS	COUNTRY	RG-COBF
BOL	Bolivia	2,106
BRA	Brazil	2,227
COL	Colombia	2,234
ARG	Argentina	2,355
CRI	Costa Rica	2,927
CHL	Chile	2,959
KOR	Korea	2,980
HND	Honduras	3,264
PRY	Paraguay	3,277
ESP	Spain	3,324
MEX	Mexico	3,410
TTO	Trinidad y Tobago	3,464
ECU	Ecuador	3,469
NIC	Nicaragua	4,031
EST	Estonia	4,152
SLV	El Salvador	4,301
PAN	Panama	4,400
BLZ	Belize	4,822
DOM	Dominican Republic	5,153
BHS	Bahamas	5,304
GTM	Guatemala	5,337
GUY	Guyana	5,825
PER	Peru	6,603
JAM	Jamaica	6,670
VEN	Venezuela	6,973
BRB	Barbados	9,026
URY	Uruguay	9,802
HTI	Haiti	
SUR	Suriname	

Source: García Zaballos and Iglesias (2018).
Note: No data available for Haiti and Suriname.

Annex 2. Country Categorization Framework: Ranking of the Market Concentration for Mobile Broadband

<3,333	Unconcentrated
3,333–5,000	Moderately concentrated
>5,000	Highly concentrated

INITIALS	COUNTRY	RG-COBM
BRA	Brazil	2,495
SLV	El Salvador	2,681
PAN	Panama	3,022
ESP	Spain	3,022
CHL	Chile	3,214
ARG	Argentina	3,248
PER	Peru	3,255
COL	Colombia	3,326
EST	Estonia	3,417
BOL	Bolivia	3,491
PRY	Paraguay	3,644
VEN	Venezuela	3,686
KOR	Korea	3,766
GTM	Guatemala	3,864
URY	Uruguay	4,001
ECU	Ecuador	4,029
CRI	Costa Rica	4,187
DOM	Dominican Republic	4,587
NIC	Nicaragua	4,808
MEX	Mexico	4,850
BRB	Barbados	5,001
SUR	Suriname	5,003
GUY	Guyana	5,085
TTO	Trinidad y Tobago	5,151
HND	Honduras	5,154
BLZ	Belize	5,221
JAM	Jamaica	5,784
BHS	Bahamas	10,000
HTI	Haiti	

Source: García Zaballos and Iglesias (2018).
Note: No data available for Haiti.

Annex 3. Country Categorization Framework: Ranking of Fixed Broadband Penetration

>25	High Penetration - Fixed Broadband
10-25	Medium Penetration - Fixed Broadband
<10	Low Penetration - Fixed Broadband

INITIALS	COUNTRY	IN-LBAF
KOR	Korea	42
BRB	Barbados	31
EST	Estonia	31
ESP	Spain	31
URY	Uruguay	27
TTO	Trinidad y Tobago	24
BHS	Bahamas	22
ARG	Argentina	18
CHL	Chile	17
CRI	Costa Rica	15
BRA	Brazil	14
COL	Colombia	13
MEX	Mexico	13
PAN	Panama	11
ECU	Ecuador	10
GUY	Guyana	8
JAM	Jamaica	8
VEN	Venezuela	8
SLV	El Salvador	7
PER	Peru	7
DOM	Dominican Republic	7
BLZ	Belize	6
PRY	Paraguay	4
BOL	Bolivia	3
GTM	Guatemala	3
HND	Honduras	3
NIC	Nicaragua	3
HTI	Haiti	
SUR	Suriname	

Source: García Zaballos and Iglesias (2018).
Note: No data available for Haiti and Suriname.

Annex 4. Country Categorization Framework: Ranking of Mobile Broadband Penetration

>70	**High Penetration - Mobile Broadband**
40-70	**Medium Penetration - Mobile Broadband**
<40	**Low Penetration - Mobile Broadband**

INITIALS	COUNTRY	IN-LBAM
EST	Estonia	133
CRI	Costa Rica	117
KOR	Korea	113
URY	Uruguay	112
ESP	Spain	96
BRA	Brazil	90
CHL	Chile	88
BHS	Bahamas	82
BOL	Bolivia	76
SUR	Suriname	76
ARG	Argentina	67
MEX	Mexico	64
PER	Peru	64
PAN	Panama	61
SLV	El Salvador	56
DOM	Dominican Republic	56
ECU	Ecuador	53
BRB	Barbados	51
VEN	Venezuela	50
COL	Colombia	49
JAM	Jamaica	49
PRY	Paraguay	48
TTO	Trinidad y Tobago	46
BLZ	Belize	30
NIC	Nicaragua	30
GUY	Guyana	26
HND	Honduras	24
GTM	Guatemala	10
HTI	Haiti	

Source: García Zaballos and Iglesias (2018).
Note: No data available for Haiti.

Annex 5. Country Categorization Framework: Output of the Regressions

	1	2	3	4	5	6
PE-PTIC	3.47 0.01*				1.61 0.15	0.25 0.86
PE-PTIC		2.30 0.00**			2.16 0.00**	2.07 0.00**
RG-VSLY			4.71 0.00**			2.68 0.02*
RG-EFAU				0.90 0.00**	0.42 0.18	0.30 0.33
Pct. Urban	0.02 0.66	0.14 0.00**	0.00 0.98	(0.02) 0.66	0.14 0.00**	0.13 0.00**
GDP per capita PPP	0.00 0.00**	0.00 0.00**	0.00 0.00**	0.00 0.00**	0.00 0.00**	0.00 0.00**
Year	2.88 0.00**	2.48 0.00**	2.83 0.00**	2.68 0.00**	2.61 0.00**	2.65 0.00**
Intercept	(5,803) 0.00**	(5,006) 0.00**	(5,695) 0.00**	(5,392) 0.00**	(5,264) 0.00**	(5,351) 0.00**
Adj. R^2	0.74	0.81	0.74	0.74	0.80	0.80
N	176	153	175	180	149	148

Source: Authors' elaboration.
Note: The upper number in each cell of the table above represents the coefficient. The lower number, the p-value, which is the estimated probability that there is no relationship between the independent variables and the dependent variable, where a p-value < 0.05 is generally considered to be statistically significant. Statistically significant results are noted as * (p < 0.01) and **(p < 0.001).

Explanation of variables

AC-UINT (number of Internet users per 100 Inhabitants): Used as the dependent variable in the above regressions.

PE-PDBA (current status of broadband development plans): Measures the degree of implementation of national broadband plans by the government. Each country, will be assessed in connection to their official broadband plan; if broadband appears in plans, agendas and others but is not strictly treated under an official plan; if broadband is in the analysis stage by the government; or if broadband is totally absent. Measures are as follow: 1: Countries with absent broadband, 3.33: Countries with broadband in the analysis stage, 5.66: Countries with broadband in plans, agendas and others, but without national broadband plan, and 8: Countries with national broadband plan.

The multivariate regressions identified this variable as the most correlated with the number of Internet users per 100 inhabitants. All five of the case study countries (Korea, Spain, Estonia, Ecuador and Chile) achieved the highest score possible on this variable, which is 8, so this variable does not seem to be driving the differences in Internet penetration.

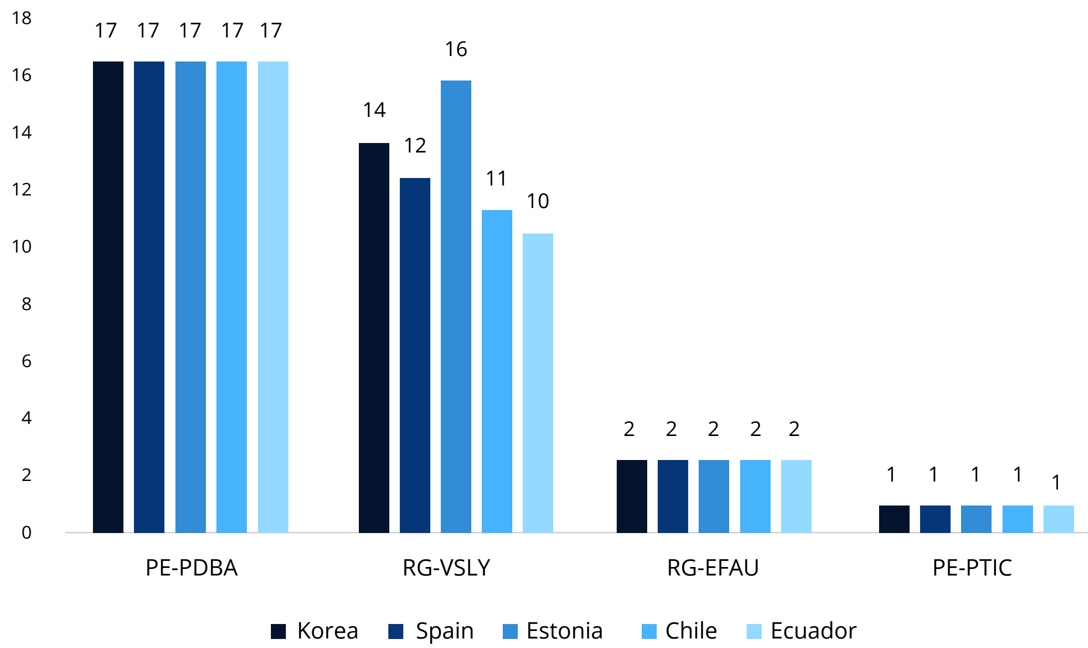
RG-VSLY (ICT regulatory framework): It refers to the survey question: How do you consider the laws that legislate the ICT environment? [1 = nonexistent; 7 = Well defined]. The ICT regulatory framework has statistical significance in some specifications. This variable shows more variation consistent with high Internet penetration rates.

RG-EFAU (effectiveness of Universal Service and Access Fund): Measures the degree of implementation and execution of the fund for access and universal service in each country. First, it will be evaluated if each country normatively enables the provision of a fund for universal access and service, and secondly, the degree of effective use of that fund in initiatives and programs aimed at social inclusion will be evaluated. 1: Countries that do not enable a universal access and service fund, 4.5: Countries that do enable a universal access and service fund but do not use it for projects with a broadband component, 6.25: Countries that do enable a fund and use, but in a limited or reduced way and 8: Countries that do enable a fund and use it reasonably. This variable lost significance when combined with other variables.

PE-PTIC (Government's role in ICT acceleration): It refers to the survey question: Do you think that the decisions made by the current government accelerate technological innovation? [1 = Not at all; 7 = Totally]. This variable lost significance when combined with other variables.

Annex 6 below shows the variables (weighted by the regression coefficients) for the five case study countries subject of this report for 2017.

Annex 6. Variables for the Five Case Study Countries



Source: Authors' elaboration, based on data from IDB (2020).
Note: The variables were weighted by the regression coefficients.

Annex 7. Technologies for Middle and Last Mile

Technology type	Down-upstream rate (technical standard max.)	Efficiency range (technical standard max.)	Infrastructure architecture	Suitability	Future of the technology
WIRED BROADBAND TECHNOLOGIES					
ADSL **ADSL 2** **ADSL 2+**	24/3 Mbps	5 km (last mile)	• Internet access by transmitting digital data over the wires of a local telephone network copper line terminates at telephone exchange (ADSL) or street cabinet (VDSL). • **Vectoring:** Elimination of cross talks for higher bandwidths. • **G.Fast:** Frequency increase up to 212 MHz to achieve higher bandwidth.	• Use of existing telephone infrastructure. • Fast to upgrade. • Small efficiency range due to the line resistance of copper connection lines. • Reliable broadband service for most residential and small business owners within 5 km distance. • High operation costs and low deployment costs (US$300-500 per HH for upgrade from ADSL by putting fiber into the networks).	• Further speed and range improvements by enhancing and combining new DSL-based technologies (phantom mode, bonding, vectoring). • Bridge technology towards complete optical fiber cable infrastructure.
VDSL **VDSL2** **Vectoring**	100/40 Mbps	1 km (last mile)			
G.Fast	Gbps bandwidths possible	100 m (last mile)			

Technology type	Down-upstream rate (technical standard max.)	Efficiency range (technical standard max.)	Infrastructure architecture	Suitability	Future of the technology
WIRED BROADBAND TECHNOLOGIES					
Community Antenna Television (CATV)	200/100 Mbps	2-100 km (last mile)	• Coaxial cable in the streets and buildings; fiber at the feeder segments. • Network extensions to provide backward channel functionality.	• Use of existing cable television infrastructure. • Fast to install. • High transmission rates. • Represents a challenge for servicing rural communities. • Speed varies greatly at different times of the day. • Medium operation costs and low deployment costs (US$400-800 per urban HH; US$800-4000 US per rural HH).	• Further implementation of new standards (DOCSIS 3.1 & 3.1 full) will allow to provide higher bandwidth to end-users.
Optical fiber cable	10/10 Gbps (and more)	10-60 km (middle mile); also last mile in FTTC, FTTB and FTTH	• Signal transmission via fiber. • Distribution of signals by electrically powered network equipment or unpowered optical splitters.	• Highest bandwidth capacities. • High efficiency range. • Low susceptibility to interference. • Medium maintenance costs. • High investment costs. • Bandwidth depends on the transformation of the optical into electronic signals at the curb (FTTC), building (FTTB) or home (FTTH). • FTTH low operation costs and low deployment costs (US$500-1000 per urban HH; US$1000-5000 per rural HH). • Low sustainability for rural deployment.	• Next generation technology to meet future bandwidth demands.
WIRELESS BROADBAND TECHNOLOGIES					
LTE (Advanced 4G)	(10/30 1000/30 Mbps)	3-6 km (last mile)	• Sites connected to a cabled communication network and switching system.	• Highly suitable for coverage of remote areas (esp. 800 MHz). • Quickly and easily implementable. • Shared medium. • Limited frequencies.	• Commercial deployment of new standards with additional features (HSPA+,5G) and provision of more frequency spectrum blocks (490 - 700 MHz).
HSPA/HSPA +(3G)	42.2 / 5.76 Mbps/ 337 Mbps/ 34 Mbps	3 km (last mile)			
HSPA/HSPA +(3G)				• Medium/high operation and deployment costs. • Suitable for rural deployment but with speed limitations.	• Meets future needs of mobility and bandwidth accessing NGA-service.

Technology type	Down-upstream rate (technical standard max.)	Efficiency range (technical standard max.)	Infrastructure architecture	Suitability	Future of the technology
		WIRELESS BROADBAND TECHNOLOGIES			
5G	10/20 Gbps	3-6 Km (last mile)	• Mobile devices send and receive radio signals with any number of cell site base stations fitted with microwave antennas.	• High achievable data rates. • Low latency. • High reliability. • Higher frequency bands. • Advanced multi-antenna transmission. • Handling of extreme device densities. • Flexible spectrum usage. • Medium/high operation and deployment costs (US$400 per HH); suitable for rural deployment but with speed limitations.	• Meets future needs of mobility and bandwidth accessing NGA-services. • Enables connectivity for a wide range of new applications.
Satellite	30/10 Mbps	High (middle and last mile)	• Sites connected to a cabled communication network and switching system.	• In general, satellite technologies are more used for middle mile or international networks. In some cases, suitable for coverage of remote areas. • Quickly and easily implementable. • Run time latency. • Medium/high operation and deployment costs.	• 30 Mbps by 2020 based on next generation of high-throughput satellites.
Low Earth Orbit (LEO) Satellites	Signal distribution to user via Wi-Fi/LTE/HSPA	Last mile	• Low to medium operation and deployment costs; suitable for rural deployment but with speed and latency limitations.	• Reduced latency. • Affordable Internet access. • Controlling by the necessary ground stations of non-stationary flying satellites is very challenging. • Medium operation and implementation costs.	• Internet service for very rural and remote areas possible.
High altitude platforms (e.g. Internet balloons)	Signal distribution to user via Wi-Fi/LTE/HSPA	Last mile	• Low to medium operation and deployment costs; suitable for rural deployment but with speed and latency limitations.	• Currently in a testing phase. • Controlling by the necessary ground stations of non-stationary flying balloons is very challenging. • Low operation and deployment costs.	• Internet service for very rural and remote areas possible.

Technology type	Down-upstream rate (technical standard max.)	Efficiency range (technical standard max.)	Infrastructure architecture	Suitability	Future of the technology
WIRELESS BROADBAND TECHNOLOGIES					
Wi-Fi (802.11n) (IEEE 802.11ad)	600/600 Mbps (7 Gbps)	200 m (10 m) (last mile)	• Medium operation and deployment costs (dependent on size of village and technology). • Could be used for rural deployment with speed limitations. • More suitable to operators with no dedicated spectrum.	• Inexpensive and proven quickly and easily implementable. • Small efficiency range. • Shared medium.	• Increased use of hotspots at central places. • Gets continually replaced by Wi-Fi and LTE. • Further developments are not expected.
WiMAX (IEEE802.16 e)	6/4(Mbps) (70 Mbps)	50 km (middle mile) for fixed use and up to 5 km for mobile usage.			
Lifi (Light Fidelity)	Max 224 Gbps	Several meters (last mile)		• Only delivers communication over short ranges. • Low reliability. • High installation costs. • Cheaper than Wi-Fi. • Only effective and permanent within closed rooms.	• Useful in electromagnetic sensitive areas such as in aircraft cabins, hospitals and nuclear power plants without causing electromagnetic interference.
Drones	<30 Mbps	Last mile	• Unmanned aerial vehicles. • Helicopter drone platform. • Cell on Wheels (COW) tTechnology. • Solar panels for power generation.	• Being tested. • Suitable for last mile despite speed, fly time and recharging limitations. • Advertised as affordable Internet.	• Hydrogen fuel cells to address issues of fly time and recharging limitations. • Perching capabilities for maintaining altitude without spending energy or deviating from data gathering tasks.
TV White Spaces	30 Mbps	Around 10 km (middle and last mile)	• Towers, internal, dedicated or external antennas.	• Medium operational and deployment costs due to UHF spectrum and lower masts. • Could be used for rural deployment with speed limitations; useful in difficult terrain.	• Possibly in M2M communication.

Source: Adapted from EC (2020).

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