Challenges in the Growth of Fiber in Latin America and the Caribbean

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Contents

Abstract

In the period from 2016 to 2021, the countries of Latin America and the Caribbean (LAC) reported a four-fold increase in the number of households passed by fiber to the home (FTTH) and a rise of 10 times the number of subscribers to this technology. Estimated penetration towards the end of 2021 was 27 percent (46 million households) and is expected to reach 60 percent by 2030, when coverage will achieve the natural ceiling expected for the region of 81 percent of households. Having adequate fiber infrastructure will be key to introducing new digital technology solutions and accompanying the growth of 5G as well as the evolution of Wi-Fi 6 and 7 capable of supporting high levels of traffic and low latencies. This technological transition is taking place amidst an evolution in the connectivity infrastructure value chain, with a trend towards the vertical disintegration of traditional internet providers and towards more specialized infrastructure management, with InfraCos, NetCos, and CloudCos as the necessary neutral partners of the final service providers. This paper analyzes these topics, bearing in mind the impact of digital infrastructure deployment on the digital transformation of the region's countries.

About the Authors

Antonio García Zaballos is lead telecommunications specialist in the IDB's Connectivity, Markets and Finance Division and Coordinator of the IDB Broadband Platform. Antonio has broad experience in the telecommunications sector, in which he has held different positions of responsibility. In Deloitte Spain, he led the regulation strategy for Latin America and the Caribbean, and he was previously Chief Economist at Telefónica's Cabinet for Economic Studies of Regulation (Gabinete de Estudios Económicos de la Regulación) and Deputy Director of the Economic Analysis and Markets Department at Spain's telecommunications regulatory body, the CMT. Throughout his professional career, he has been a consultant for regulators, telecommunications operators, and governments in countries such as Saudi Arabia, China, Ecuador, Argentina, Dominican Republic, Paraguay, Poland, and the Czech Republic, among others. Antonio has served on different technical committees of experts including the World Economic Forum's Internet for All initiative and the United Nations Broadband Commission. He holds a Ph.D. in Economics from Madrid's Carlos III University and is an Associate Professor of Applied Finance for Telecommunications at the Instituto de Empresa Business School and of Economic Regulation at Johns Hopkins University. He is the author of diverse papers on economic-regulatory aspects applied to the telecommunications sector.

Sebastián M. Cabello is an expert in public digital policies and a consultant for diverse entities of the public and private sector. He is currently CEO of SmC+ Digital Public Affairs and advisor to several firms and multilateral organizations and chambers. He is also an affiliated researcher at the Center of Technology and Society (CETyS) at San Andrés University, Argentina. From 2010 to 2018, he was the Director General of Global System for Mobile Communications Association (GSMA) in Latin America, where he led the regional agenda on behalf of the mobile industry. He has been a member of the Internet for All committee of the World Economic Forum (WEF) and led and coordinated numerous regional public-private initiatives, such as the Latin American Telecommunications Congress (CLT), the CE-Digital training center, the Nos Importa campaign, the Comercio Digital Sin Fronteras (CDSF) program, the Broadband Environment for Sustainable Transformation (BEST) network of the Inter-American Development Bank (IDB), and the DigiEcon Latam event, among others. He has a degree in Economics from the National University of the South (UNS), Argentina, and holds a master's in International Relations from the University of California, San Diego (UCSD). He was a Fulbright scholar from 2003 to 2005 and has given classes at the University of Palermo Business School and taught Economics at both the UNS and the University of El Salvador (Argentina).

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Maribel Dalio is an expert in digital transformation and development. She has more than 10 years' experience in leadership of public digital infrastructure and inclusion policies, performing functions at local, national, and international levels. She was the Director of Institutional Relations at the Ministry of Modernization of the National Government of Argentina, where she was in charge of three coordinating agencies. She worked as a consultant for the Office of the Cabinet of Ministers of Argentina and for diverse governments of Latin America, and she was the Director of Electoral Technologies for the Government of the Autonomous City of Buenos Aires (CABA) during the first implementation of electronic voting. In the international sphere, she has worked with different institutions such as the G20, OECD, UN, ITU, European Union, IDB, and the World Bank. She has studied at universities in six different countries, including Harvard and Brown Universities. She has a master's in Executive Coaching and Leadership from the University of Barcelona and a degree in International Relations from the Catholic University of Córdoba. She is currently working for the Connectivity, Markets and Finance Division (CMF) of the IDB as a consultant on digital infrastructure and inclusion.

Executive Summary

The deployment of fiber optic cables is enjoying a moment of opportunity in the world and in the Latin American and Caribbean (LAC) region in particular. Recent years have seen consistent growth in fiber-to-the-home (FTTH) broadband connections due to the demand for greater bandwidth and lower latencies—requirements that traditional copper and cable-based networks cannot cover—and to their lower relative cost compared to replacing existing wiring.

At present, LAC countries report growth rates in the period 2016–2021 of 4 times the number of FTTH-ready households and 10 times the number of subscribers to such technology. Estimated penetration toward the end of 2021 was 27 percent (46 million households) and is expected to rise to 60 percent by 2030, when the coverage will reach its expected natural ceiling for the region of 81 percent of households.

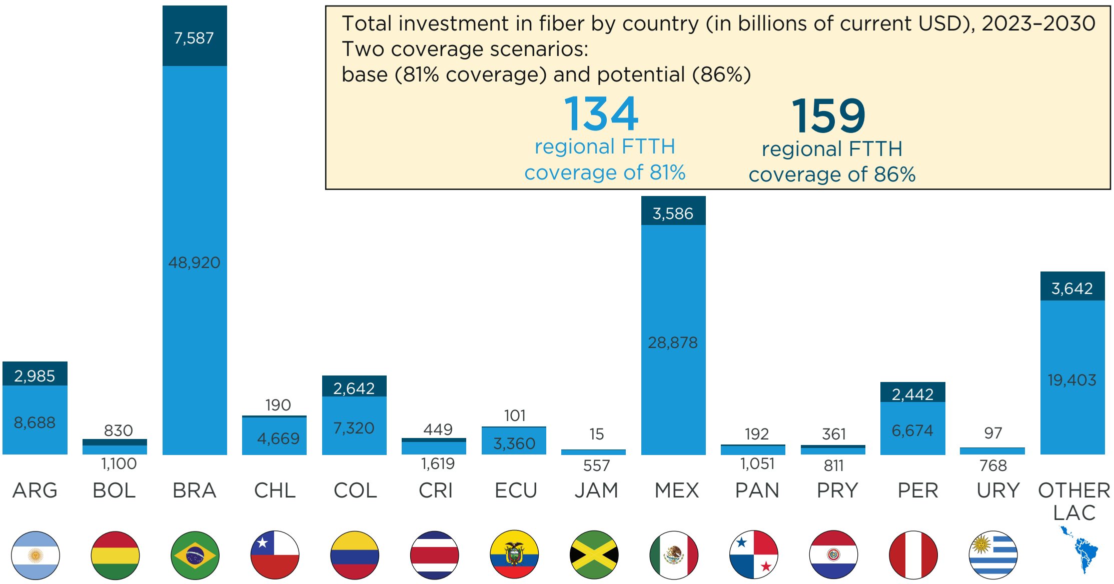
The survey carried out in 17 countries of the region shows coverage levels above the regional average of 59 percent in Barbados, Brazil, Chile, Jamaica, Trinidad and Tobago, and Uruguay. Therefore, the regional average penetration of 27 percent is surpassed in Barbados, Brazil, Chile, Trinidad and Tobago, and Uruguay. The LATAM Chapter of the Fiber Broadband Association (FBA) estimates that the take-up rate will rise from 45 percent in 2021 to 71 percent in 2027. Comparatively, the European Union (EU) reached a take-up rate of 52 percent in 2021, which means that the LAC region is at least two years behind Europe, where Spain stands out as one of the most advanced countries.

Having adequate fiber infrastructure will be key to introducing new digital technology solutions and accompanying the growth of 5G, as well as the evolution of Wi-Fi 6 and 7 that will support high levels of traffic and low latencies. This technological transition is taking place in the midst of an evolution in the connectivity infrastructure value chain, in which there is a trend towards the vertical disintegration of traditional internet providers, with more specialized infrastructure management such as InfraCos, NetCos, and CloudCos becoming the neutral partners final service providers need.

Establishing incentives for the deployment of fiber and harmonized rules at the

Figure A.

Total Investment in Fiber by Country, 2023–2030



Source: Authors' elaboration.

sub-national level will be key to maintaining the rhythm of investments and extending the benefits of fiber beyond where the market would naturally reach. At present, diverse barriers to deployment must be overcome, among which administrative and regulatory obstacles predominate due to the lack of coordination and harmonization of regulations at the different levels of government. At the same time, the costs of fiber are currently increasing and there is a noticeable lack of necessary skills, which may create bottlenecks for growth. To sustain and maximize such growth, sooner rather than later it will be critical to have dig-once policies, provide incentives for sharing and coordination by all actors, and stimulate demand with subsidies and benefits to ensure that every household has the opportunity to become a subscriber.

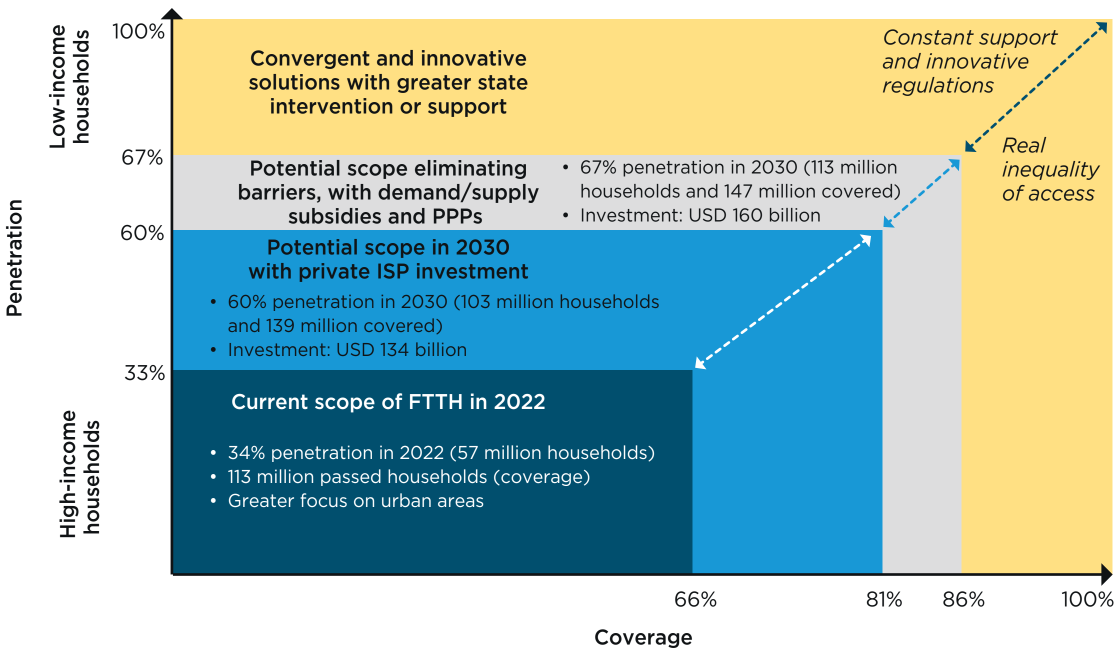
Achieving average coverage in the region of around 80 percent of households, both urban and rural, implies a major challenge for a region where, on average, 82 percent of households are urban. This implies that, in 2022, the estimated coverage in urban areas will be greater than the regional average (around 78 percent) and that coverage will be very low in rural areas (15 percent). The average estimated ceiling to which FTTH can aspire in the region is 81 percent (93 percent in urban areas and 29 percent in rural areas). In order for the market to achieve this projected trajectory, investments to the tune of USD 134 billion are expected for the entire region, with Brazil and Mexico combined representing 44 percent of the total.

It must also be remembered that many of the investments will be made in the areas with the highest purchasing power, which means there will be more overlapping of networks in those places. Wherever overlapping networks exist, greater competition and options for consumers can be expected. According to studies, deployment costs are doubled in rural areas, and costs are also around 17–20 percent greater if cables are underground rather than overhead. According to these projections and estimates, a model was constructed to evaluate how these market insufficiencies could be solved by reducing barriers through smart supply subsidies (enhancing coverage) and stimulation of coordination (more public-private partnerships [PPPs]) and demand (boosting access).

The 81 percent coverage expected by 2030 is a possible ceiling for the region, but smart policies could stretch coverage still further to 86 percent and enable penetration to go higher than the proportional

Figure B.

Matrix of Spaces with Fixed Broadband Coverage and Penetration Applied to FTTH



Source: Authors' elaboration.

67 percent. These five percentage points would imply connecting more than 10 million additional households in areas of lower commercial attractiveness and lower average income, which would be possible through a total investment of USD 160 billion.

Introduction

This paper was born from the dialogue that followed the agenda of collaboration between the Inter-American Development Bank (IDB) and the Fiber Broadband Association (FBA) Latin American Chapter[1] for the promotion of fiber deployment with a view to improving robust connectivity in Latin America and the Caribbean (LAC) and helping to narrow the digital gap.

The LAC region is not isolated from the phenomenon of increasing optical cable installation in the developed world where, in the United States for example, this technology has been chosen to receive USD 42.45 billion in funding from the National Telecommunications and Information Administration (NTIA) of the Broadband Equity, Access and Deployment (BEAD) program. Similar investments have been seen in Europe, where in February 2023 the Organisation for Economic Co-operation and Development (OECD) had already highlighted an increase of 12.3 percent in fiber subscribers over the last year (from June 2021 to 2022), and where fiber represents 36 percent of subscribers among the 38 OECD members (OECD, 2023).

The most notable figures are from South Korea, Japan, and Spain, which record the highest rates of fiber penetration in the OECD with 87 percent, 84 percent, and 81 percent, respectively, and are among the seven OECD countries in which fiber represents 70 percent or more of the total fixed broadband subscribers. The highest fiber growth rates in LAC are seen in Costa Rica, Chile, and Colombia (51 percent, 35 percent, and 32 percent, respectively), whereas in Europe they are recorded in Belgium, the United Kingdom, and Ireland (87 percent, 47 percent, and 40 percent, respectively).

This paper seeks to expand the knowledge of progress of fiber in LAC by studying its achievements and projecting its performance in 17 countries. It breaks new ground in the sense that the growth of fiber is a relatively recent phenomenon of which there is limited knowledge and for which specific public policies are rare, beyond efforts by different governments over the last decade

[1] This organization publishes annually the FTTH LATAM Panorama. Part of this paper is based on their surveys and estimates.

to promote national backbone networks with mixed success. This paper describes, from a decentralized and private sector perspective, how the fiber value chain functions and it highlights the public policies that promote its deployment. Thereafter, the cost is estimated, as well as the investments needed to continue the expected trajectory in which some countries, such as Brazil, Chile, and other smaller Caribbean countries, are the most advanced. Finally, some of the persistent challenges are addressed, alongside best practices and how public-private collaboration will be fundamental when it comes to supporting growth and investment projections.

1

The "Moment of Opportunity" for the Growth of Fiber in LAC

The deployment of optical cable is experiencing a moment of opportunity in the world and in the LAC region in particular. The deployments of fiber to the home (FTTH)[2] have reported constant growth in recent years due to the demand for greater bandwidth and lower latencies—requirements that the traditional copper- and cable-based networks are unable to provide—and due to fiber's relatively lower cost compared with replacing existing wiring.

In effect, internet service providers (ISPs) have begun to migrate their networks towards fully fiber optic networks, starting with hybrid deployments and now reaching homes. Governments in the region have understood that their involvement in the deployment of fiber is key to reducing digital exclusion.

Accumulated growth between 2016 and 2021 has been four-fold in the number of households passed by FTTH/B (103 million in December 2021) and there are now 10 times the number of FTTH/B subscribers (46 million in December 2021), driven mainly by Brazil and Mexico. Box 1 defines some of the main terms related to the fiber market and its dynamics.

With respect to the difference between coverage and penetration of FTTH services, it is important to clarify that coverage will always be greater than penetration. Many households are passed by fiber but are not targeted commercially by the firm or, if they are, the users may choose not to contract the service, contract it from another broadband provider that serves the household, or already possess alternative

[2] The concept of FTTx comprises different hybrid models in which the fiber network does not reach the home but points prior to the home, from which it enters the home through existing copper networks. These models may be to the building (FTTB), to the cabinet (FTTC), or to the node (FTTN).

Box 1

Main Definitions of Fiber Optic Deployments

Installation: House or building that may be connected by an FTTH or FTTH/B network.

Socket or connector: Point of connection in the household/installation of a single fiber service provider. There may be multiple connectors (sockets) if the location is served by multiple FTTH network operators.

Passed households: Potential installations that a service provider has the capacity to connect to an FTTH network/FTTB with minimal additional work.

Subscribers: Number of installations that are connected to a network and subscribed to a broadband service.

Coverage: Ratio between passed households and total number of households in the country.

Penetration: Ratio between subscribers and total number of households in the country.

Take-up: Ratio between subscribers and passed households in the country, or between penetration and coverage. This is a significant ratio for the industry, given that it helps to understand the level of conversion from passed households to subscribers.

technology with sufficient speeds for their economic needs and range. Furthermore, a high take-up rate does not necessarily signify that there is high coverage. In Europe,[3] the rate of take-up reached 48.5 percent by September 2021, which shows that the investment effort in preparing households is still very much higher than the commercial capacity to convert such households into FTTH service subscribers. Nonetheless, it is worth remembering that the investment required to convert a passed household into a subscriber is significantly greater than that of the initial deployment (see Figure 1).

In 2021, FTTH in LAC reached 59 percent coverage (13 percentage points [pp] more than in December 2020) and 27 percent penetration (9 pp more than in December 2020).

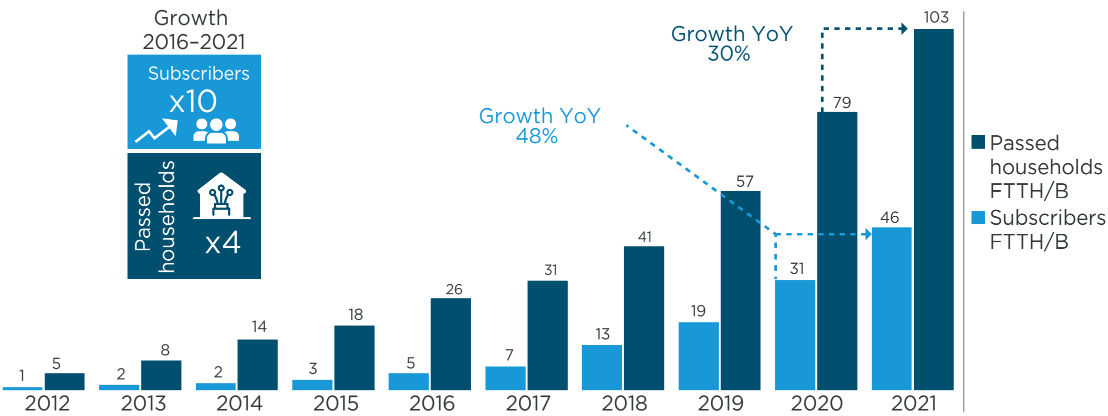
Countries and Their Household FTTH Coverage

As previously mentioned, by the end of 2021 LAC had deployed fiber networks to the home, reaching 103 million households passed by FTTH/B, which represents coverage of 59 percent. These 103 million

[3] The five European countries with the highest levels of take-up, according to the FTTH Council Europe, are Finland (96 percent), Iceland (94 percent), Sweden (77 percent), Spain (77 percent), and Portugal (74 percent).

Figure 1

Subscribers and Fiber-Ready Households in LAC (in millions)



Source: Ros Rooney et al. (2022).
Note: YoY: year-on-year.

households include households in which more than one operator has deployed fiber,[4] which mainly happens in the urban centers (i.e., areas of greater population density and with greater purchasing power).

The deployments of fiber in LAC are concentrated in five countries that account for 90 percent of the total households passed by FTTH/B. Brazil, with 52 million passed households, represents 51 percent of the region, followed by Mexico with 22.5 million, Argentina with 7.5 million, Chile with 5.3 million, and Colombia with 4.2 million (Figure 2).

As in Brazil, which is the leader in the region with regard to passed households, other countries reported a significant evolution in their deployments of FTTH/B in 2021. The Bahamas, Colombia, Peru, and Puerto Rico had stand-out annual growth rates in 2021 of over 30 percent (Table 1).

Detail of FTTH Subscribers by Country

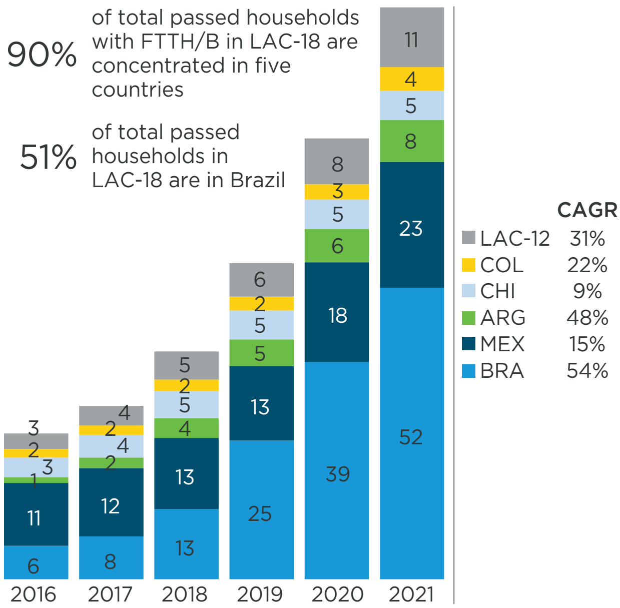
Towards the end of 2021, the region had reached 46 million subscribers, which represents 27 percent FTTH penetration. Growth has been extremely rapid in recent years and has been multiplied by a factor of 10 since 2016.

It is important to remember that, in the case of FTTH, the term "subscribers" refers to households, not individual persons, with a contracted FTTH service. If the average number of inhabitants per household in each country is considered, the number of inhabitants with an FTTH subscription would be around 144 million.[5]

[4] The passed households were estimated using an overlap ratio between operators, thus avoiding duplication of households in the estimate.
[5] This is an estimate based on the average number of persons per household, without any kind of

Figure 2

Households Prepared for FTTH/B in LAC (in millions)



Country	Passed households	Total households	% of total deployments
BRA	52,361,268	69,700,000	25%
MEX	22,500,000	38,850,000	42%
ARG	7,500,000	14,000,000	46%
CHL	5,299,248	6,910,000	23%
COL	4,250,893	14,100,000	70%
ECU	2,520,192	5,800,000	57%
PER	2,309,601	8,400,000	73%
BOL	1,218,000	3,330,000	63%
URY	1,110,000	1,245,000	11%
PRY	688,350	1,800,000	62%
JAM	653,465	958,000	32%
CRI	628,190	1,600,000	61%
PRI	570,092	1,200,000	52%
TTO	470,000	500,000	6%
PAN	346,535	1,100,000	68%
BRB	108,000	122,000	11%
BHS	59,200	111,000	47%
Total	**103,087,158**	**169,726,000**	**40%**

Source: Ros Rooney et al. (2022).
Note: CAGR: compound annual growth rate.

Table 1

LAC Countries with Highest Growth of Households Passed by FTTH/B, 2021 vs. 2020

Growth of Passed Households			
Country	**Percentage**	**Country**	**Number of Households**
Puerto Rico	+229%	Brazil	+13,300,000
Peru	+56%	Mexico	+4,600,000
Colombia	+56%	Argentina	+1,500,000
Bahamas	+40%	Colombia	+1,500,000
Brazil	+34%	Peru	+902,000

Source: Ros Rooney et al. (2022).

Countries such as Brazil (26.3 million), Mexico (9.3 million), Chile (2.4 million), Argentina (2.1 million), and Ecuador (1.4 million) represented 90 percent of total LAC subscribers in December 2021. These countries also report the highest rates of growth over the last five years (Figure 3).

Panama, Puerto Rico, Paraguay, Bahamas, and Costa Rica, in that order, were the five principal countries in terms of subscriber growth in 2021 (Table 2).

Significant Disparity in Deployments in the Region

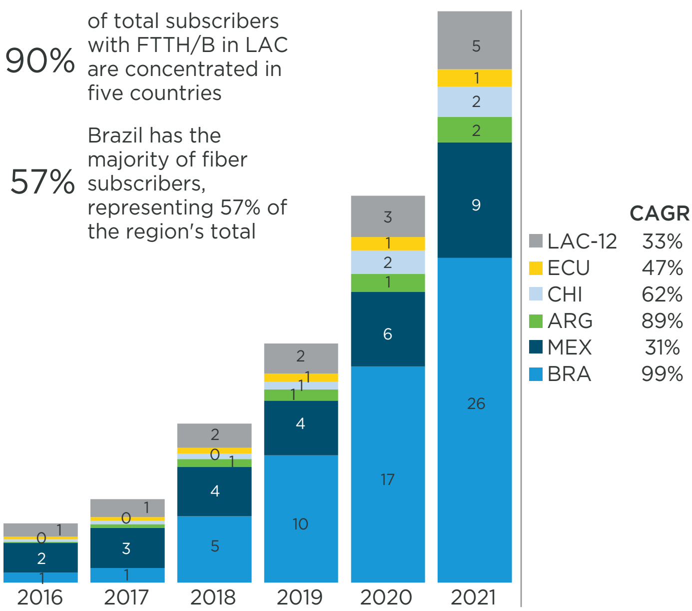
Towards the end of 2021, average FTTH coverage in LAC reached 59 percent, however, only 6 of the 17 countries studied have surpassed this figure. Brazil, Chile, and Uruguay are the leaders in the Southern Cone region, and Barbados, Jamaica, and Trinidad and Tobago are leaders in the Caribbean (Figure 4). As also shown in Figure 4, the region achieved average penetration of FTTH/B of 27 percent, but only 5 of the 17 countries studied have achieved a higher-than-average rate of penetration. Barbados and Uruguay were leaders, followed by Trinidad and Tobago, Brazil, and Chile.

Due to its expansive territory and number of inhabitants, the case of Brazil deserves

adjustment by region or by socioeconomic level (the first FTTH deployments always take place in the areas with the highest socioeconomic level).

Figure 3

FTTH/B Subscribers in LAC (in millions)



Country	Subscribers (households)	Subscribers (individuals)
BRA	26,293,000	80,180,446,92
MEX	9,349,400	31,027,975,31
CHL	2,426,744	6,713,406,41
ARG	2,078,000	6,735,094,86
ECU	1,420,625	4,321,394,29
COL	1,398,422	5,046,419,02
URY	880,289	2,455,617,43
PER	661,378	2,595,987,39
BOL	478,500	1,677,336,49
PRY	339,193	1,343,958,04
CRI	285,700	909,597,38
TTO	216,500	575,032,23
JAM	142,254	406,864,26
PRI	118,952	319,365,20
BRB	99,750	229,915,57
PAN	66,025	258,938,05
BHS	14,700	54,019,98
Total 2021	**46,269,432**	**144,851,369**

Source: Ros Rooney et al. (2022).

Table 2

LAC Countries with Highest Growth of FTTH/B Subscribers, 2021 vs. 2020

Growth of Subscribers			
Country	**Percentage**	**Country**	**Number of Subscribers**
Panama	+113%	Brazil	+8,800,000
Puerto Rico	+68%	Mexico	+3,300,000
Paraguay	+63%	Argentina	+648,000
Bahamas	+60%	Chile	+541,000
Costa Rica	+49%	Colombia	+491,000

Source: Ros Rooney et al. (2022).

special mention, given that by 2021 it had achieved coverage of 75 percent and penetration of 38 percent, which is above the regional average in both indicators. In contrast with the situation in other countries, in Brazil smaller ISPs and/or those of regional scope have been very important in driving deployments; in December 2021 they represented 47 percent of all passed households.

The region presents significant digital exclusion. The disparities with regard to FTTH may have diverse motives that hamper or impede adoption of this technology by operators and service providers in the region's countries.

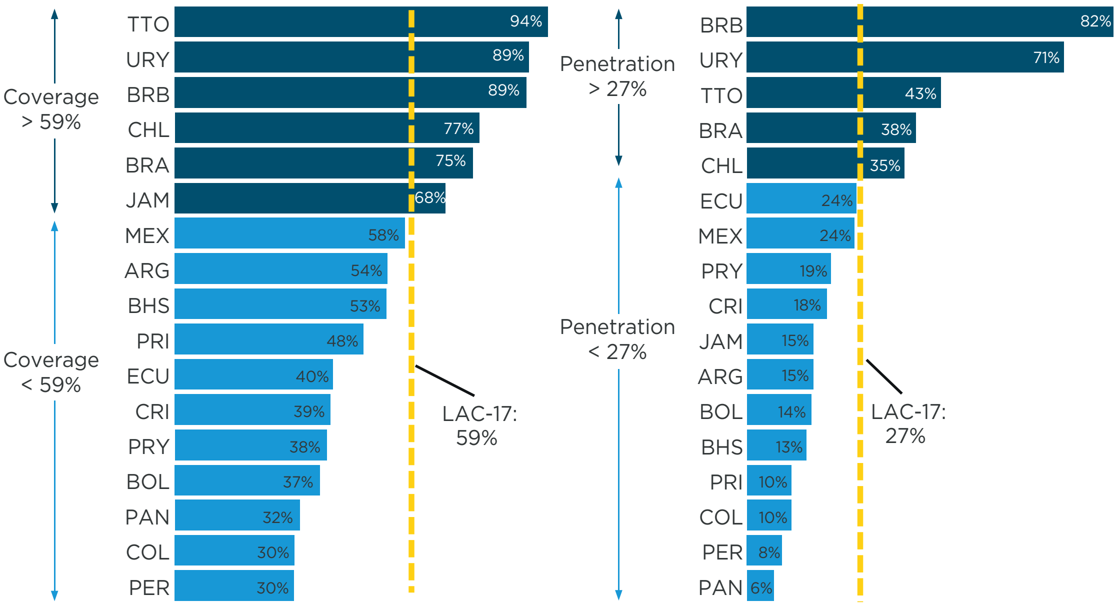
These motives include: (i) the high cost of updating a legacy network of copper or cable; (ii) networks still offer a competitive bandwidth that is acceptable for end internet users; (iii) the lack of regulatory incentives from government authorities; (iv) the return on investment, which is a very sensitive driver when it comes to boosting the deployment of fiber in markets with lower average revenue per user (ARPU) and extreme fluctuations in the value of the local currency; (v) supply chain difficulties and higher prices; and (vi) geographical characteristics (mountain ranges, islands, rain forests, etc.) and vast territories that make these remote areas unattractive at the economic level.

FTTH Is Expected to Achieve a Penetration of 57 Percent and Coverage of 80 Percent in the Region by 2027

Since 2016, there has been a change in the trend of FTTH, which has now become the chosen technology for many network operators when making new offers and expansions to reach new customers.

Figure 4

Coverage and Penetration of FTTH in LAC Countries, December 2021



Source: Ros Rooney et al. (2022).

Such increased fiber optic penetration can be explained, principally, by three motives:

- New subscribers in areas where fiber has already been extended to the household, so the increase depends solely on a commercial effort without significant investments in deployments because they have already been made.
- Replacement of copper wiring in areas already seeing demand for service with greater speed and lower latency.
- Installation of fiber in greenfield development sites.[6]

The deployment of fiber optic networks enables the implementation of a flexible access network using fiber capable of supporting the broadband service requirements of both residential and non-residential users via FTTH. Likewise, it allows for the convergence of telecommunications services within a single network infrastructure, which favors reduced costs for operators, because they avoid having to install and maintain parallel networks for each service.

It is expected that the region will achieve 99 million subscribers by 2027, based on the

[6] A greenfield project is one that is either started from zero or is an existing project that is entirely transformed.

operators' aggressive business strategies and also on a technological migration that mainly cable operators will make towards complete FTTH solutions for their existing customers.

With respect to passed households, it is estimated that there will be 139 million by 2027, with growth of 21 percent from 2022 to 2027 (Figure 5).

It is estimated that the rate of coverage will reach 80 percent of total households in the region in 2027, driven by deployments of fiber to provide FTTH coverage at the national level. Brazil, Chile, Puerto Rico, Trinidad and Tobago, and Uruguay will be the principal protagonists in this growth. When it comes to expectations about the number of passed households by 2027, the most notable are Brazil with 60 million, Mexico with 30 million, Argentina and Colombia with 11 million, Chile and Peru with 6 million, and Ecuador with 4 million.

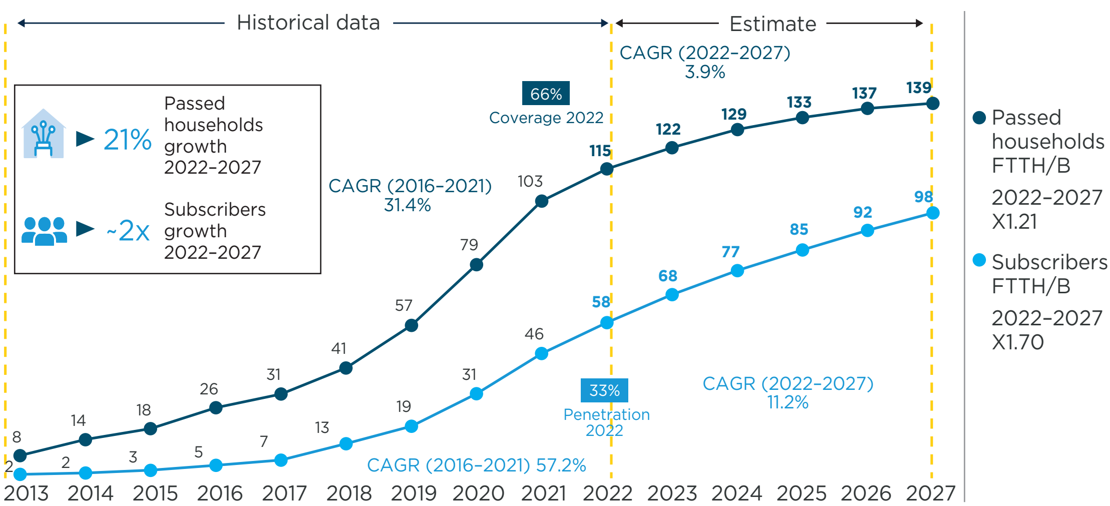
The penetration of FTTH will see an increase of 30 pp from 2021 to 57 percent by the end of 2027. This will be the result of the expansion of FTTH coverage to more households, commercial efforts by operators, and demand that increasingly requires more high-speed, low-latency broadband services (Figure 6).

As can be seen in Figure 6, it is expected that the growth trend of subscribers will be greater than that of passed households, as a consequence of commercially exploiting existing deployments and of widespread growth of the service.

The uneven growth in coverage and penetration will result in an increase of the take-up rate, which will rise from 45 percent

Figure 5

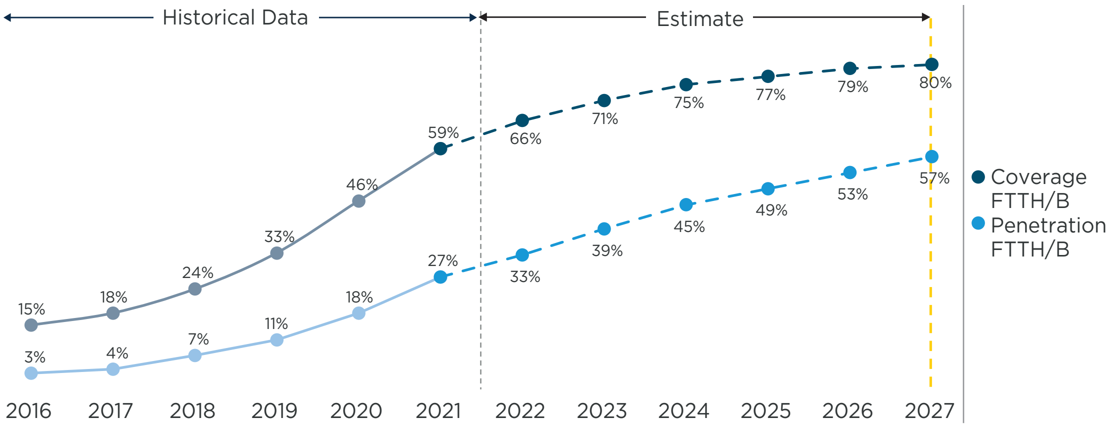
Estimate of Passed Households and FTTH Subscribers in LAC (in millions)



Source: Ros Rooney et al. (2022).

Figure 6

Coverage of Households and FTTH Penetration in LAC



Source: Ros Rooney et al. (2022).

in 2021 to 71 percent in 2027 (see Table 3). On the basis of the expected growth of this indicator, it may be said that LAC is two years behind more developed markets, such as Europe, given that the European Union (EU) reached a take-up of 52 percent in 2021 and LAC expects to achieve 56 percent by 2023.

Table 3

Estimate of Passed Households and Subscribers in LAC, 2021–2027

Country	2021		2022		2023		2024		2025		2026		2027	
	Passed households	Subscribers	Passed households	Subscribers	Passed households	Subscribers	Passed households	Subscribers	Passed households	Subscribers	Passed households	Subscribers	Passed households	Subscribers
ARG	7,500,000	2,078,000	9,232,800	2,849,000	9,971,424	3,555,000	10,569,709	4,314,000	10,992,498	5,146,000	11,164,256	6,044,000	11,387,541	6,930,000
BHS	59,200	14,700	75,286	17,474	85,073	34,125	91,028	49,750	94,669	65,575	96,563	75,700	98,494	78,200
BRB	108,000	99,750	115,000	104,450	115,200	108,700	115,200	112,000	115,200	115,200	122,000	117,600	122,000	120,100
BOL	1,218,000	478,500	1,385,900	696,700	1,524,490	829,800	1,661,694	938,800	1,778,013	1,021,950	1,902,474	1,107,550	2,035,647	1,195,550
BRA	52,361,268	26,293,000	54,158,358	31,583,745	56,151,386	35,884,000	57,992,415	39,372,000	59,207,203	42,228,000	59,958,564	44,846,000	60,217,208	47,003,000
CHL	5,299,248	2,426,744	5,349,124	2,942,058	5,502,739	3,441,850	5,719,475	3,909,606	5,874,028	4,334,667	6,012,685	4,664,559	6,080,743	4,913,058
COL	4,250,893	1,398,422	6,234,211	2,156,129	7,991,379	3,137,229	9,684,615	3,902,300	10,320,339	4,525,700	10,807,563	5,102,500	11,267,500	5,502,050
CRI	628,190	285,700	812,850	391,040	933,005	505,450	983,542	603,210	1,032,719	698,000	1,074,028	788,410	1,127,730	890,490
ECU	2,309,601	1,420,625	2,936,800	1,493,834	3,515,946	1,791,380	4,017,331	2,130,833	4,297,396	2,538,524	4,512,266	2,860,524	4,605,041	3,304,258
JAM	653,465	142,254	672,059	146,344	698,941	198,267	719,842	254,543	741,437	302,228	756,266	358,845	756,698	392,457
MEX	22,500,000	9,349,400	25,568,919	12,132,000	26,266,800	14,551,214	27,274,877	16,495,302	28,463,782	17,971,864	29,583,550	19,580,599	30,013,991	21,333,338
PAN	346,535	66,025	519,802	119,000	720,792	203,000	755,455	305,000	791,304	412,000	803,833	515,000	810,264	592,250
PRY	688,350	339,193	1,142,453	484,000	1,267,290	605,000	1,331,345	726,000	1,348,863	842,160	1,355,265	936,482	1,376,371	1,009,902
PER	2,520,192	661,378	3,930,476	1,226,100	5,272,897	1,839,150	5,642,000	2,482,853	5,976,994	3,103,566	6,355,843	3,569,100	6,610,077	3,926,011
PRI	570,092	118,952	801,905	215,000	973,043	334,000	1,099,219	455,000	1,150,000	574,000	1,194,512	689,000	1,200,000	787,000
TTO	470,000	216,500	474,534	252,000	480,588	265,000	481,938	270,000	486,888	287,000	488,297	297,000	490,321	319,000
URY	1,110,000	880,289	1,121,000	967,887	1,143,420	1,016,044	1,154,854	1,054,405	1,166,403	1,081,562	1,180,000	1,096,439	1,190,000	1,098,364

Source: Ros Rooney et al. (2022).

In addition to the commercial objectives and strategies of private players, the region is undergoing changes in terms of establishing digital agendas as a way of reducing exclusion and narrowing the digital gap. This will bring on board new fiber subscribers who were previously outside the coverage zone.

The countries of the region present different plans that seek to promote the expansion and deployment of the existing fiber optic infrastructure and thereby reach a greater number of persons with better technical services and economic conditions. These digital agendas are focused chiefly on providing coverage in rural or remote areas, which, in the absence of such plans, private operators often fail to reach due to the scant economic attractiveness of these regions.

Table 4 presents some government programs that involve the deployment of optical fiber cable in their territories.

Table 4

Government Plans for the Development of Fiber Optic Networks

Country	Government Program	Deployment of Fiber	Notes
ARG	Red Federal de Fibra Óptica (REFEFO)	31,876 km of optical fiber (2022) 38,808 km of optical fiber by 2023	1,105 localities connected (2021)
BRA	Norte Conectado	12,000 km (program total)	Reaches 59 cities and 10 million people
CHL	Fibra Óptica Nacional (FON)	10,000 km (program total)	Started in 2019–20, with public funds of over USD 100 million
COL	Plan Nacional de Fibra Óptica (PNFO)	19,000 km (program total)	98 percent progress (installation phase and commissioning); operational phase pending
PER	Red Dorsal de Fibra en Perú (RDNFO)	13,000 km of fiber deployed (2021)	Interconnection of 22 regional capitals and 180 provincial capitals

Source: Authors' elaboration based on public information.

2

Complementarities of Fiber and Different Connectivity Solutions

Overcoming connectivity gaps in LAC requires making intelligent use of different technologies and solutions to achieve the ultimate goal of connecting the unconnected and empowering local firms and communities to boost local economic and social development.

For service providers, it is becoming increasingly clear that it is impossible to maximize coverage with a single technology; a combination must be used to adjust to every need. It is also evident that fiber is the fundamental basis of robust connectivity from wireless services to the cables that connect end users, as is the case of FTTH.

In effect, optical fiber is a necessary (albeit insufficient) way to provide connectivity via undersea cables, backbone networks, and last-mile deployments, even reaching the household (in the case of FTTH). In addition to fixed connectivity, fiber is also a key component in the transport of mobile connectivity, given that it connects the antennas (and small cells in upcoming 5G deployments). At present areas with greater population density and higher purchasing power already have coverage, but this is not true of rural and remote areas.

Having Adequate Fiber Infrastructure Will Be Key for the Introduction of New Digital Technology Solutions

As previously mentioned, optical fiber is the means for providing robust connections because it is a scalable technology due to the high levels of bandwidth it can manage as well as its low levels of latency. In this sense, optical fiber is used to support the main infrastructures that provide connectivity, such as high-capacity undersea cables, backbone networks, domestic networks (pure or hybrid), and mobile connectivity technologies.

As demand accelerates and internet data traffic grows, the digital infrastructure must be updated worldwide. Fiber optic networks are key for developing the mobile evolution of 5G/6G, Wi-Fi 6/7, and the evolution of FTTx environments. As the networks evolve, new use cases and business models will appear, and fiber optic will be at the center of this land connectivity ecosystem. Convergent connectivity will even merge with the satellite solutions that are being developed and that will provide a necessary complement for expanding beyond the robust connectivity that fiber provides today.

With respect to mobile device connectivity, the same depends to a large extent on fixed high-capacity networks that can provide high bandwidth to the mobile repeater stations. The evolution of new technologies, such as 5G, is obliging operators to support them via backbone and backhaul networks with higher transmission capacity—essentially optical cable—and to concentrate antennas and cells with the aim of guaranteeing robust bandwidths, reducing latency, and ensuring service stability. For example, 5G coverage in medium and high bandwidths requires deployments not only of macro cells but also of small cells with a significant urban capillarity that will demand connectivity through optical cable (fiber to the antenna [FTTA]).

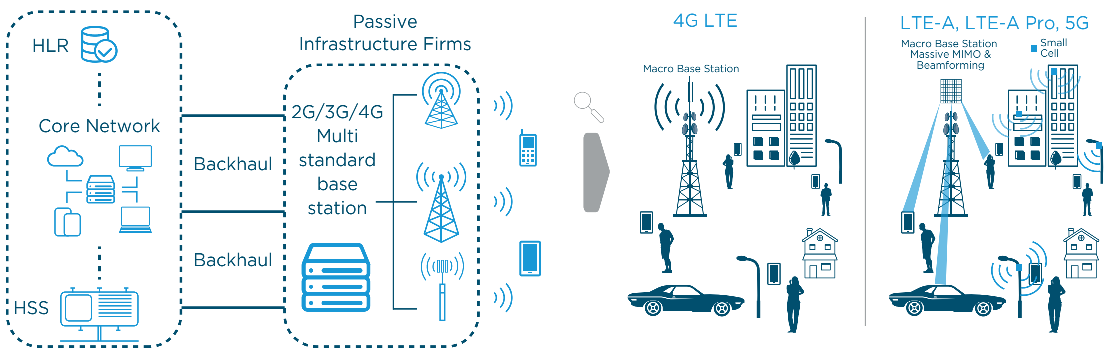
The 5G networks will bring new opportunities for the industry and innovations in terms of architecture (see Figure 7), given that they will have to be equipped with strong infrastructure, of which the following are the most notable types:

- **Ultra-dense (UDN) or small cell networks:** Given the limited quantity of spectrum available in low bandwidths, the design of the current 2G, 3G, and 4G networks will be insufficient to support the services 5G is expected to offer. The high-frequency spectrum lacks the propagation properties necessary for 5G to reach its maximum potential. Therefore, high densification of the small cells—that is, siting the antenna closer to the end user, whether through installations in public spaces, businesses, or strategic points—will be vital for this new technology. The demands of ultra-low latency for applications such as robotics, self-driving cars, and others will need this type of infrastructure.
- **Large-scale transition to fiber:** The high performance offered by 5G from base stations must be backed by the operator's central network, which must be capable of delivering optimal performance while coping with high demands. This will lead to the deployment of fiber in the majority of base stations.
- **Use of macro cells:** Most of the data traffic burden will continue to be managed by the macro cells. This means that, before deploying new technology infrastructure to service innovative applications, operators must have a clear strategy for improving their current transport networks, which are the ones that underpin the macro networks.

Wi-Fi and 5G are going to perform complementary roles to satisfy diverse

Figure 7

General Diagram of a Mobile Telephone Network and Its Density Challenges

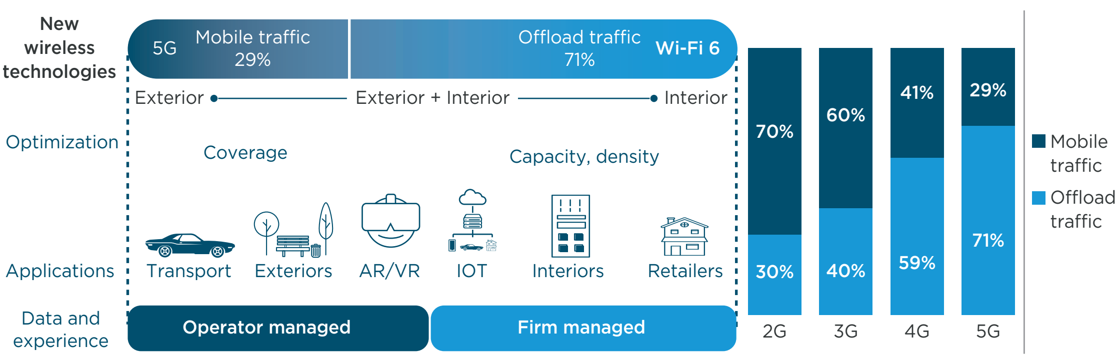


Source: Authors' elaboration.
Note: MIMO: multiple input multiple output.

connectivity demands and specifications (see Figure 8). The different optimization models by which both of these technologies have been designed, both internally (favoring capacity and density) and externally (favoring coverage and mobility), will permit an infinite number of applications and uses. The use of spectrum that is licensed and managed by operators will require subsidiary and complementary action by unlicensed spectrum that is managed by each business or household. Estimates made by Cisco, for example, claim that 5G will generate an increase in offloading from

Figure 8

Mobile Traffic and Offload Via Wi-Fi Networks, Projected for 2022



Source: Authors' elaboration, based on Cisco estimates.
Note: AR/VR: augmented reality/virtual reality; IOT: Internet of Things.

fixed networks using Wi-Fi[7] in comparison with previous technologies (for example, offload in 4G was 59 percent, while 5G is expected to achieve 71 percent).

The deployments of new technologies will be accompanied by new models in which fiber and 5G will be associated,[8] such as:

- **Private networks:** Consisting of autonomous networks whose components are housed in a single installation comprised of micro towers connected to an organization's local area network (LAN) and its business applications.
- **Neutral host:** This type of network provides added value services enabling mobile operators to improve the delivery of internal and external connectivity to their subscribers.
- **New smart cell models:** In this type of 5G network, each firm will have its own implementation environment and face its own challenges regarding optimal installation and administration of small cell connectivity.

Figure 9 presents some of the new applications with emerging technologies that will be supported by 5G and Wi-Fi 6/7; ultra-low, medium, and managed latency requirements; and the infrastructure needs for each one of them. In effect, establishing robust fiber optic–supported networks, both backhaul and download, will be fundamental when it comes to supporting all these new applications with high data demand.

To ensure that this new range of services and applications, supported by technologies of the so-called fourth industrial revolution, can be developed wirelessly and with mobility, much greater densification of the networks will be needed with more heterogeneous operating models using massive multiple input multiple output (MIMO) antennas and a significant number of small cells, in which all sites must be interconnected with fiber optical cable.

Evolution of the Connectivity Infrastructure Value Chain and the Role of Fiber

The advance of fiber and its business models for infrastructure management allow for a range of possible business models. A value chain can be identified that ranges from the traditional tower operators (TowerCos) as neutral owners seeking to expand the diversification of their businesses to the hyperscale companies, known as CloudCos, and including, depending on the level of integration in the value chain, the InfraCos and NetCos models.

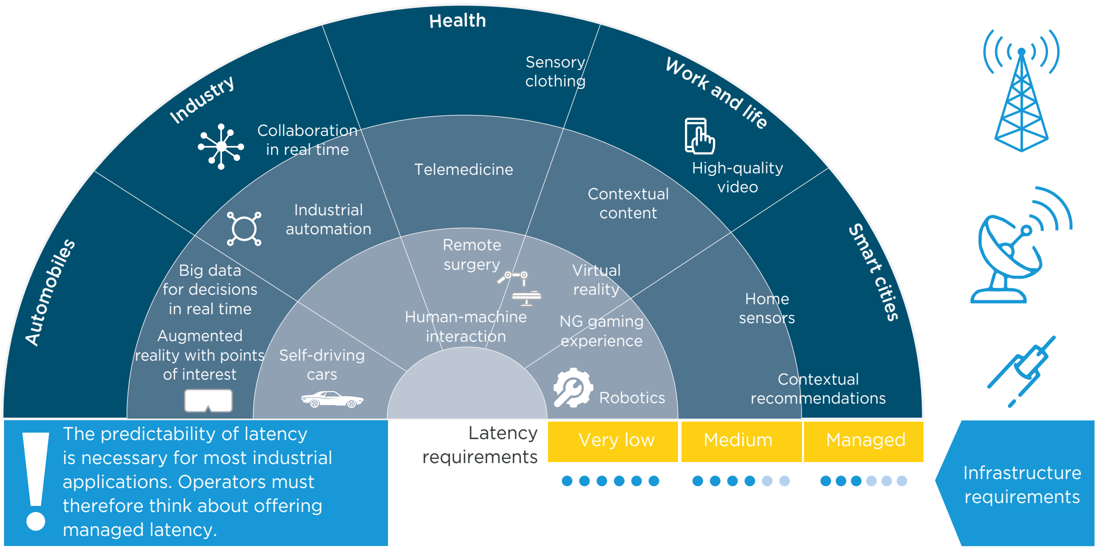
The current model (TowerCos) seeks network efficiency, by which the infrastructure company is concerned only with the infrastructure's administration and management. In a further step towards integration, in the

[7] The offload traffic refers to the routing of traffic from mobile networks to other alternative access technologies with local coverage that usually have shorter transmission ranges, such as Wi-Fi.

[8] Analysis by SmC+, from the Small Cell Forum's neutral hosts requirements database.

Figure 9

New Connectivity Applications with Emerging Technologies and Vertical Latency Requirements



Source: Authors' elaboration, based on Detecon and IBM.

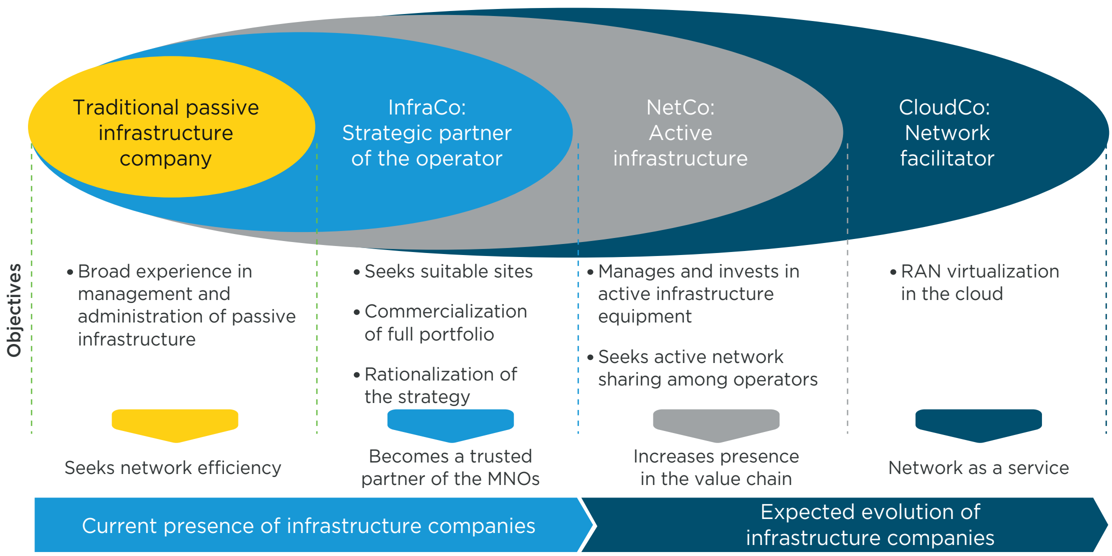
InfraCos model, the passive infrastructure firm becomes a strategic partner of the communications service provider, by which the administration and management of the sites are outsourced and leased from it. The NetCos model incorporates the management and investment objective into active infrastructure equipment. Finally, and with total integration of the value chain, the CloudCos model considers the network as a service, which is offered by the infrastructure firm, virtualizing the radio access network (RAN) in the cloud and deploying microdata centers (Figure 10).

In the LAC region, the presence of InfraCos has helped traditional mobile operators to update and implement new technologies. Mobile operators have sold their infrastructure assets (towers and datacenters) in order to lighten their balance sheets and reduce their capital needs. The InfraCos are now the ones making the big disbursements for new infrastructure deployments, which permits operators to convert their capital investments into operating costs.

Furthermore, the neutral fiber optic network business is also experiencing significant growth in the region in recent years. Large mobile service providers have shed their fiber optic businesses and decided to drive new business models through vertical disintegration of the business by launching new neutral networks, as in the case of

Figure 10

New Digital Connectivity Infrastructure Business Models



Source: SmC+, based on data from Barclays.
Note: MNO: mobile network operator.

OnNet Fibra in Colombia and Chile[9] or the consolidations observed in Brazil following the break-up of the operator Oi into V-tal and the launch of other operators such as FiBrasil (Table 5).

The deployment of neutral fiber networks makes infrastructure available to all interested operators or providers to mitigate capacity demands or, in the case of small and medium ISPs, enabling them to offer connectivity in areas that previously lacked access due to the high investment costs involved. New business models are also beginning to emerge in greater numbers, such as virtual network operators (VNOs), thanks to agreements that make infrastructure available on demand that is deployed by neutral networks in their target niche markets.

A further case to highlight is the VNO, which is a network management provider that resells network services. The VNO does not often possess the telecommunications infrastructure to provide solutions for its customers, but instead it hires bandwidth at wholesale prices from different telecommunications providers. One example of this is the firm Liwa[10] in Colombia, which utilizes the neutral network infrastructure of OnNet Fibra and has agreements with DirecTV for the provision of pay-per-view television content.

[9] American global investment company KKR (Kohlberg Kravis Roberts & Co) acquired 60 percent of Movistar FiberCo by paying USD 600 million in Chile and USD 200 million in Colombia.
[10] More information about Liwa is available at https://www.liwa.co/.

Table 5

Some Recent Infrastructure Transactions in LAC

Firms involved	Year	Assets involved	Amount (millions of USD)	Comments
TIM FiberCo IHS	2021	Fiber: 6.4 million (passed households)	311	IHS bought a 51 percent share in FiberCo, the fiber optic company of TIM in Brazil.
Telxius AM Tower	2021	30,722 sites	9,400	Sale of the Telxius of Telefónica tower business in LAC to American Tower.
Telefónica KKR	2021/22	60 percent of the fiber optic network	200	Telefónica sold 60 percent of its FTTH business in Colombia to KKR.
Telefónica KKR	2021/22	60 percent of the fiber optic network	600	Telefónica sold 60 percent of its FTTH business in Chile to KKR.
Mundo Digital Bridge	2022	100 percent of the fiber optic network	N/A	The Digital Bridge investment fund bought Mundo in Chile (the most extensive fiber optic network).
Telefónica FiBrasil CDPQ	2022	Fiber: 1.6 million (passed households)	500	The Telefónica Group and CDPQ reached an agreement for the creation of a neutral fiber network: FiBrasil.
Algar Highline	2022	125 sites	11	Highline Brazil closed the acquisition of mobile sites from the regional operator Algar Telecom.
ENTEL OnNEt Fibra	2022	Fiber optic business	360	Telefónica and KKR, through their fiber optic subsidiary group OnNet, acquired the Entel network in Chile.

Source: SmC+, based on Fitch Ratings 2022.

3

The Importance of Providing Incentives for Deployment and Harmonized Rules at the Sub-National Level

Many of the region's governments seek to narrow the digital gap through digital plans or agendas. However, at both the national and the municipal level, rather than incentives for providers to deploy new fiber networks there are barriers and bureaucratic red tape that can delay or limit the process of implementing new infrastructure.

Although the great majority of governments recognized the essential nature of telecommunications services as COVID-19 emerged, only a few understood the critical role of digital infrastructure. The restrictions and barriers to deployment of digital infrastructure are well known, and they include too much (or too little) regulation, long administrative response times, disproportionate royalty payments, lack of legal security, restrictions on distance from sensitive sites or land use, lack of clear rules, and disinformation in the community, among others.

The Need to Promote Both Infrastructure Deployment and Sharing

Competition in infrastructure networks, which originally meant that every operator was the owner of their own network, has long been at the center of policy to regulate the telecommunications sector in both the Americas and in EU countries. However, in a high densification scenario, overlapping networks may be not onlyy economically inefficient but might create insurmountable barriers to entry for new players and have an undesired impact on the environment.

As the players and their service provision conditions change, regulations and public policies in the sector must also adjust to encourage the efficient use of resources, such as infrastructure sharing and co-investment agreements. This is the case in some of the new wholesale networks, such as the rural wholesale operator Internet para Todos in Peru.[11]

In this way, regulation regarding the sharing of passive infrastructure seeks to resolve an efficiency problem that derives from the lack of competitive coordination and, in particular, from the use of assets that are not easy to share—particularly in urban areas—for the production of services.

It is worth remembering that a significant part of the passive infrastructure deployed by other public services, such as gas, water, or electricity, can also be used for telecommunications services. In this sense, the public service companies that carry out civil works, financed totally or partially by the state, should be expected to satisfy the reasonable requests of telecommunications firms regarding coordination of civil works, with the aim of deploying high-speed broadband networks. This is the case in the EU, where Directive 2014/61/EU,[12] regarding measures to reduce the cost of deploying high-speed electronic communications networks, addressed such obligations.

In a similar vein, to achieve an efficient and shared use of passive infrastructure, it is essential to guarantee that operators have access to accurate information about the availability of buildings, public spaces, or sites. This requires developing computer systems that show georeferenced data regarding such infrastructure, as well as supporting the processes to request their use, provision, and maintenance. If the passive infrastructure to be shared belongs to a dominant operator, implementing these systems can form part of the obligations imposed in return for access. If the infrastructure also comprises elements supplied by other public service providers and/or other infrastructure, facilities, or buildings belonging to the state, the public administration should help manage the consolidation of data from different organizations to make the use of those assets much simpler (see Box 2).

The Barriers to Fiber Deployment Are Related to Both National and Municipal Concerns

A common problem at the global level, and in particular in LAC, has to do with the powers of different government authorities to grant permission regarding the elements that affect service provision. In the case of telecommunications, the local or municipal authorities generally possess the constitutional autonomy to give permits for infrastructure installation and rights of way for the laying of optical cable. Therefore, if these authorities are not aligned with national public policy, they can interfere with the

[11] Find out more at https://www.ipt.pe/.

[12] See https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0061.

Box 2

Success in Spain

The case of Spain provides an inevitable benchmark for LAC, as its efforts to promote the deployment of fiber have made it a leader in Europe and the OECD. According to the OECD, by June 2022, 82 percent of the total fixed broadband connections in Spain were carried out using fiber. This fact gives the Spanish network a robustness surpassed only by South Korea and Japan.

Various factors led to Spain being especially prepared to deploy super-fast broadband networks. Following the recession of 2008–2013, in which the country lost a tenth of its gross domestic product (GDP), a competitive environment that boosted investment was promoted. Operators were given access to the high-quality civil infrastructures needed to connect optical cable to the household. This included sewers, conduits, posts, and access to buildings, as well as the obligation for landlords to provide access to optical cable infrastructure in their buildings. The Spanish regulations obliged the incumbent operator to allow wholesale access in some places and also created incentives for operators to deploy their own fiber networks if they wanted to access speeds higher than 30 megabits per second, a limit which the incumbent operator was obliged to provide. This meant that other operators deployed their own networks to compete for ultra wideband services. In this way, sharing agreements were also reached that went beyond the regulations and the obligations contained therein.

Thanks to these conditions, deployment grew strongly to even surpass Spain's more developed neighbors and eventually take up pole position on the old continent. In 2008, the country was in fourteenth place, in 2010 it was ninth, in 2012 it had risen to sixth, and by 2014 it was in first place in the region. According to the European FTTH/B Market Panorama 2023 of the FTTH Council Europe (2022), it was estimated that by 2022 around 88 percent of Spanish households had access to super-fast broadband.

provision of telecommunications and internet services that are under national or federal jurisdiction (depending on each case).[13]

In most of the region's countries, local regulation has taken precedence over national or federal directives, which has led it to become extremely restrictive, non-transparent, bureaucratic, and even irrational when it comes to issuing municipal permits. Local or municipal governments exercise their powers by applying their own regulations, setting their own considerations to restrict the use of land and public spaces, or determining how to measure environ-

[13] A good discussion and proposals for the matter of federal and municipal jurisdictions and incentives can be found in Russell (2020).

mental and/or visual impact. This has generated a vast array of legislation to regulate elements that are really rather standard and common.

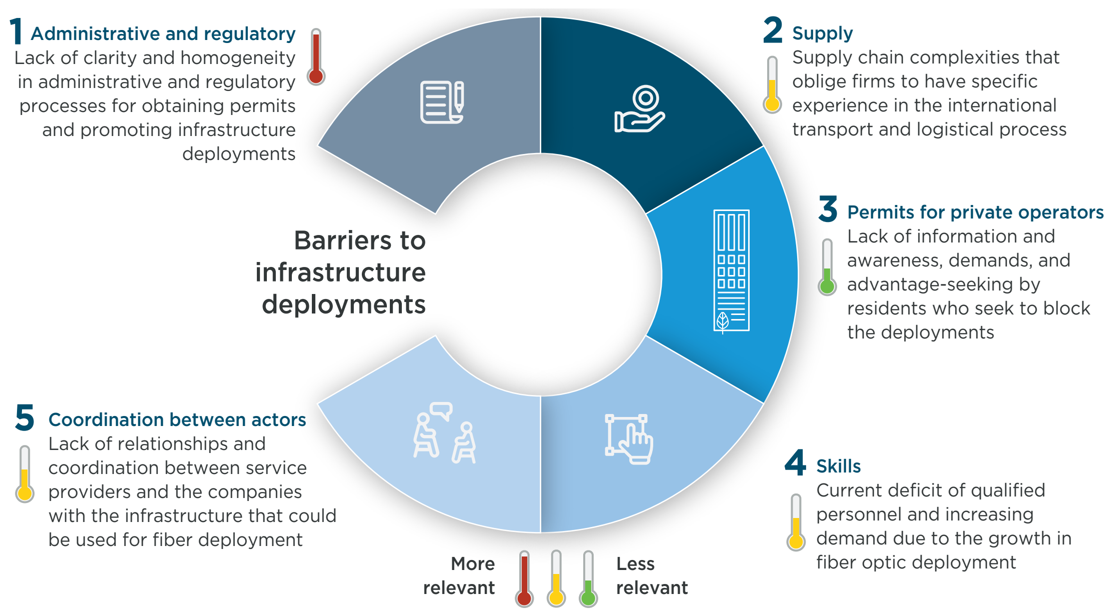
National governments have often felt that their hands are tied when it comes to implementing connectivity plans, deploying new technologies, and improving service quality. In some countries, municipalities enjoy high degrees of autonomy in deploying civil works and facilitating rights of way. As these are not standardized situations, they can become a barrier to the timely and correct deployment of technology, which causes delays in the adoption of national plans.

The barriers to the deployment of connectivity infrastructure can be grouped as follows: (i) administrative and regulatory, (ii) supply, (iii) permits for private operators, (iv) lack of skills and a trained workforce, and (v) coordination between actors. Administrative and regulatory barriers are currently the most significant and cause the most impediments to successful deployments according to market needs and time schedules (Figure 11).

Each one of the barriers to the deployment of connectivity infrastructure is described below, with examples given and particular attention paid to those that hamper the progress of optical cable deployment.

Figure 11

Types of Barriers to the Deployment of Connectivity Infrastructure



Source: Authors' elaboration.

Administrative and Regulatory Barriers: The Most Relevant

- Lack of alignment between national and sub-national organisms.
- Lack of homogeneity in requirements and requests for documentation, even in the same municipality. On the one hand, the authorities fail to understand the limits of their municipal powers, which means that they add more requirements than are strictly necessary. On the other, the multiplicity of actors often means that the same documentation is requested by multiple institutions.
- Even when they have their own administrative processes that are different from those at the national level, municipalities often lack the skills and knowledge to design efficient processes. There is a noticeable lack of awareness of the code of best practices.
- Unpredictable time periods, due to their heterogeneity and lack of legal certainty, make planning very difficult. Current timelines make time-to-market much longer for infrastructure companies and thus it is harder for them to respond rapidly and adequately to operators. Many cases end without approval, not necessarily due to rejection but a lack of response.
- Lack of regulations or ignorance of the same. Laws that hamper the deployment of infrastructure (for example, Chile's 2012 law on antennas and its real estate co-ownership law that demands very high quorums). Lack of regulation with regard to access and rights of way and RAN sharing. Lack of regulation on neutral networks. Existence of outmoded regulations, without context.
- Lack of certainty with respect to permits for the use of public spaces and goods for infrastructure installation.
- Possible impact of the declaration of internet as an essential service.

Barriers to Supply: The Importance of Understanding and Controlling the Fiber Supply Chain

- Most of the optical cable used in the deployments in the region comes from Asia, which makes it dependent on international logistics in which LAC is not a priority whenever ships or containers are scarce. At the same time, international transport costs have risen in recent years (especially following the COVID-19 pandemic).
- The high demand for optical cable in the world has led to a scarcity of raw materials, which restricts production in the factories of Asia.
- Although not quantifiable, the cultural barrier and lack of understanding with Asian providers can lead to misunderstandings that, at the end of the day, delay optical cable delivery times.
- The uneven customs clearance times and requirements in LAC lead to delays in supply and to firms needing to have detailed knowledge of such processes.

- The final delivery of optical cable in LAC faces the region's aforementioned geographical challenges (long distances, mountain ranges, and forests, among others).

Barriers to Private Operator Permits: Linked with the Direct Interests of Residents

- Highly demanding requirements that are not applicable to the buildings and/or installations in which the infrastructure and fiber optic equipment is deployed. In some cases, remunerations are demanded that are unrelated to the deployment of infrastructure and are solely for the benefit of residents or administrators.
- Lack of adequate physical space for the installation and deployment of new fiber infrastructure and equipment.
- The high costs of using spaces in buildings or housing developments for the deployment of fiber infrastructure.
- The use and existence of legacy technology in housing developments or buildings means that residents are not interested in deploying new technology.

Skills Barriers: Lack of a Qualified Work Force

- At present, there is already a deficit of personnel skilled in fiber optic installation, while future deployments will require even more qualified personnel.
- By way of example, in the United States, the National Rural Broadband Association estimates that providers already suffer from a 40 percent deficit in required materials and waiting times of over 18 months, compared to the average delay of three months that was previously expected (Sevilla, 2021). The University of Utah's Center for Growth and Opportunity claims that approximately one new technician is needed for every 1,500 to 2,000 new fiber optic subscribers.
- In LAC, there is a notable partnership between FBA LATAM Chapter and FYCO, which created the Academia FBA with the aim of implementing training programs in the region to offer knowledge and skills for the design, assembly, installation, operation, and activation of FTTx networks.

Barriers to Coordination between Actors from Electric Companies and Highway Maintenance Firms

- Lack of cooperation between service providers and traditional electricity companies or highway maintenance firms. The lack of understanding of the operational and technological needs inherent in the deployment of fiber optic infrastructures hampers the harmonization of procedures and requirements for shared infrastructure use.
- Lack of a technical assessment committee that can provide support for hierar-

chical decisions to enable the deployment of new fiber optic infrastructure that is technically viable.

- A degree of discretion in granting licenses and permits for the use of posts. It is clear that firms able to deploy their infrastructure with the support of electric companies and backed by the interest of the state can quickly and efficiently address procedures and requirements.
- Lack of a neutral actor to help combat abusive or unfair practices that jeopardize the deployment of new technology infrastructure.
- Lack of an official coordination channel to take advantage of civil works in highways, roads and streets, etc., and the deployment of new fiber networks. If the parties are able to coordinate excavation works, installation of conduits, road maintenance, and so on, repeat costs can be avoided that create obstacles and can mean higher costs for the deployment of a fiber optic network.

Policies That Promote the Deployment of Fiber

Public policy and regulatory frameworks can perform a fundamental role in fiber deployment. In recent years, the region's regulators and policymakers have made diverse efforts to reduce administrative and technical barriers for municipalities, mainly by trying to harmonize regulations. Improving predictability and transparency in the permit request process is a key element to enable potential investors to effectively finalize their plans correctly and on time. Education campaigns have also been trialed, alongside positive incentives such as, for example, promoting municipal twinning.

Any desirable solution would clearly also include implementing single points of contact at the national level, positive administrative silence, speedy permission for the use of public infrastructure, and simplified excavation procedures. This—as well as a regulatory framework that encourages the signing of commercial agreements between operators and new players for the use of existing street infrastructure, and the sharing of first passive then active infrastructure in order to achieve cost reductions and efficient investments—should be the way forward. On a secondary level of relevance, a code of best practices should be published as well as a ranking to compare cities according to the clarity of their processes and rules for infrastructure installation.

The Annex to this document presents the different regulations or initiatives to promote efficient deployment of fiber in the region, although it does not reveal the practical application of such regulation or the existence of private agreements between operators and providers. The effectiveness of the different deployment-enabling regulations varies beyond regulatory scope or ambition, given that it fundamentally depends on how effectively regulations are implemented in practice and the national authorities' capacity for alignment with sub-national governments, which enjoy autonomous powers when it comes to granting authorizations.

It is worth highlighting that, even with very diverse and generally ineffective results, the governments of the region have adopted different measures to promote deployment and sharing of connectivity infrastructure.

As the OECD and IDB (2016) point out, the following are among the specific best practices to promote the shared use of passive infrastructure:

- Require the dominant operators that own the conduits, masts, and other passive infrastructure to share them with other operators at regulated prices, even when the passive infrastructure belongs to a parent firm (such as an electric company).
- Apply dig-once policies that encourage diverse public utilities (gas, electricity, telecommunications, and water) to adhere to a common shared plan for excavation works. This measure can help reduce investment for each party involved, minimize nuisance and inconvenience in public spaces, and better organize future deployment and maintenance.
- Generally speaking, when planning new public infrastructure such as roads it is worth investing in conduits that any operator can use to deploy their own networks under conditions of open, cost-based access. This becomes especially useful when there is a lack of backbone and backhaul infrastructure.

Figure 12

Some Measures Implemented to Promote Network Deployment

Measures to promote deployment of telecommunications infrastructure	ARG	BRA	CHL	COL	CRI	ECU	MEX	PRY	PER
Infrastructure law	No	Yes	Yes	No	Yes	No	No	Proposed	Yes
Single window	Approved but not implemented	No	No	No	No	No	In certain cities	No	No
Positive administrative silence	In certain cities	Yes	No	Yes	No	No	No	No	Yes
Use of state-owned buildings or land	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Proposed
Codes or manuals of best practices	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes
Ranking (cities)	No	Yes	No	Yes	No	No	No	No	Yes

Relevance/Impact: + (top) to – (bottom)

Source: Authors' elaboration, based on information from regulators.

The cases of Brazil, Chile, and Peru are significant, given that they all have specific regulation for infrastructure deployments. Paraguay's National Telecommunications Commission (Comisión Nacional de Telecomunicaciones or CONATEL) presented a proposal in 2019 to regulate the expansion of telecommunications infrastructure, but the proposal has yet to be debated or passed into law. In Argentina, the single point of contact has been approved but not yet implemented. A further case, although lacking national scope, is seen in the state of Hidalgo in Mexico, where a procedure similar to the single point of contact exists for enabling telecommunications infrastructure.[14]

The adoption of specific technical rules for internal telecommunications networks helps to plan the construction of architectures that can support different technologies and capacities for the use and deployment of fiber. Therefore, the placement and location of underground ducts is organized in a way that supports the laying of fiber optic networks and at the same time obliges coordination between entities to avoid process duplication. In Chile, the Underground Utility Law (Ley de Ductos) seeks to make the industry more competitive and encourage investment by infrastructure companies to offer better residential telecommunications services. In Costa Rica, Law 10216[15] passed in 2022 regulates the technical arrangements for telecommunications infrastructure regarding the use of public infrastructure, highway design, underground conduits, the reservation of underground spaces, and other regulations.

The use of buildings and public lands, as well as infrastructure belonging to firms from other sectors, facilitates deployments, reduces costs and delivery times, and promotes capillarity and connectivity. Initiatives in this direction are seen in different countries and cities of the region. For example, in Colombia, the Communications Regulation Commission (Comisión de Regulación de Comunicaciones or CRC), via Resolution 5890/2020,[16] updated the conditions for infrastructure sharing in the information and communication technologies (ICT) sector alongside the electricity sector for network deployment or telecommunications service provision. The measure established new tariff limits with significant reductions for the use of posts, conduits, and towers of the electricity sector infrastructure.

There are also measures being put into place such as best practice codes or guides to homogenize application among differ-

[14] To find out more about this subject, see the document available at https://www.gob.mx/cms/uploads/attachment/file/566631/Infraestructura_de_Telecom_portal.pdf.

[15] The text of Law 10216, to Stimulate and Promote the Construction of Telecommunications Infrastructure (Ley para Incentivar y Promover la Construcción de Infraestructura de Telecomunicaciones en Costa Rica), can be found at https://www.crhoy.com/wp-content/uploads/2022/07/ley-10216.pdf.

[16] The text of Resolution 5890/2020 can be found at https://www.sic.gov.co/sites/default/files/documentos/022022/Resolucion-5890-de-2020.pdf.

ent cities and municipalities in each country. For example, Colombia's best practice code defines the technical conditions for installing new infrastructure for the expansion of coverage or new service provision, the methodology for verifying the limits of exposure to electromagnetic fields, the process for dealing with requests for authorization, and the obligations associated with such procedures.[17] In Argentina, the country's most important mobile telephone operators, the regulatory body, and the Argentine Federation of Municipalities (Federación Argentina de Municipios) signed up to the code of best practices for deploying mobile communications networks, which includes a series of municipal regulations that, among other things, regulate the way in which non-ionizing emissions are to be controlled.[18]

In a similar vein, publishing a ranking of the cities that favor deployment is a way to highlight best practices and reveal those that hamper the progress of connectivity. For example, in 2021, the city of São Paulo occupied position 90 of 100 in a ranking of internet-friendly cities in Brazil.[19] This position in the ranking was due to, among other factors, failing to attend to requests for new authorizations for the installation of antennas (in 2019, there were 700 unresolved requests for the installation of antennas and no new authorizations had been granted for two years), failing to differentiate permissions according to the type of infrastructure (for example, between small antennas and towers), and getting the approval of residents in the case of alleys with no exit.

Finally, although the region's countries have yet to implement regulations related to dig-once policies (see Box 3 for further details), their adoption can reduce investment costs for all stakeholders, minimize nuisance and disruption in public spaces, and better organize future deployment and maintenance. Applying dig-once policies that encourage diverse public utilities (roads, gas, electricity, telecommunications, and water) to adhere to a common shared plan for excavation works is key, and they could be the basis of any approval for deploying new infrastructure.

Various cities of the world (e.g., London[20] or San Francisco[21]) work with the

[17] Colombia's Code of Best Practices is available at https://www.crcom.gov.co/sites/default/files/webcrc/micrositios/documents/buenas_practicas_despliegue_2020_0.pdf.

[18] Argentina's Code of Best Practices for the deployment of mobile communications networks can be consulted at https://www.itu.int/en/ITU-T/others/sg5rglac/Documents/Presentaci%C3%B3n%20Fernando%20Fux.pdf.

[19] See the Conexis ranking of internet-friendly cities in Brazil at https://conexis.org.br/wp-content/uploads/2021/09/Ranking-Cidades-Amigas-2021_Final.pdf.

[20] London's dig-once approach is available at https://www.london.gov.uk/programmes-strategies/better-infrastructure/infrastructure-coordination/streets-service/dig-once-approach?ac-63591=63587.

[21] The San Francisco Connectivity Plan is available at https://sfgov.org/lafco/sites/default/files/FileCenter/Documents/52279-3%20City%20and%20County%20of%20San%20Francisco%20%28February%202015%29%20Connectivity%20Plan.pdf.

Box 3

Dig-Once Policy

A dig-once policy refers to how public and private sector infrastructure programs, in which public service companies and connectivity providers take part, coordinate the installation of conduits (and connectivity) while carrying out works on highways, roads, and other infrastructure projects to reduce the need for multiple excavations.

A dig-once policy is relevant for all stakeholders given that, among other advantages, it reduces nuisance and inconvenience for citizens and accelerates deployment by connectivity providers. Moreover, it reduces the administrative burden for cities and local authorities and significantly reduces the cost of connectivity connections, given that excavation works on roads and streets often account for most of the implementation budget.

In this respect, the OECD position with regard to infrastructure sharing with other sectors is "to apply 'dig-once' policies that encourage diverse public utilities (gas, electricity, telecommunications, and water) to adhere to a common shared plan for excavation works. By this measure, investment costs can be reduced for all parties involved, nuisance and inconvenience minimized in public spaces and future deployment and maintenance can be better organized" (OECD and IDB, 2016). Such policies also generate additional income that contributes to the viability of the new public infrastructure, as in the case of highways, where investment in conduits and in dark fiber constitutes a successful business case, which is moreover very useful for other operators, especially when the supply of backbone and backhaul infrastructure is scarce.

In 2020, the Fiber Optic Sensing Association (FOSA, 2020) identified that 16 states in the United States had specific dig-once policies approved by the Federal Highway Administration (FHWA), which is the body responsible for giving approval when a state decides to adopt a dig-once policy.

dig-once principle in mind, which implies setting rules for those who dig or install conduits for future uses. Dig-once policies include, for example, incentives for prioritizing approvals or accepting bids from those that promote sharing their conduits.

Similarly, the dig-once policy is considered fundamental for the principles of the G20 Global Smart Cities Alliance policy on operational and financial sustainability and equity, inclusion, and social impact.[22]

In a World Economic Forum (WEF) article regarding dig-once policies (Glickman, 2022), three factors were identified that should be considered:

[22] The WEF's Dig-Once Model Policy is available at https://weforum.ent.box.com/v/dig-once-model-policy.

- **Greater coordination between different authorities, operators, and service providers:** Coordination between stakeholders, in particular those in the private sector, is a significant challenge when it comes to expanding digital connectivity. Firms have reacted positively to dig-once policies, but some are not ready to offer their competitors easy access to their solid fiber connections.
- **Creation of case studies and open communication between similar cities:** Irrespective of the region, cities want to learn how to implement digital connectivity collectively. Governments can learn from cities that have already adopted these policies, whereby providers are encouraged to collaborate in projects.
- **Greater data availability from the geographic information system (GIS):** Open GIS data, which can help to map existing infrastructures, are a further requirement for effective dig-once policies, because proprietary data hamper collaboration and can lead to knock-on delays. Until operators have a full understanding of where public service cables, optical cables, and conduits are buried, work cannot begin. Such delays have an impact not only on operators but also citizens who have to use the routes and services affected by the work.

To overcome these barriers, governments can develop a governance model that defines the role of each stakeholder and the processes included in a dig-once policy. This should address digital infrastructure project financing, data exchange, and the alignment of stakeholder participation that is arbitrated or facilitated by local authorities.

Role of the Private Sector and Public-Private Partnerships (PPPs) in the Coverage of Areas with Low Population Density

The way in which the expansion and penetration of broadband services have a direct and indirect impact on the economic and social development of countries has already been studied extensively. In general terms, growth in broadband internet access (in which not only the coverage but also the internet speed and service quality should be considered) translates into macroeconomic progress, specifically GDP growth, and also into microeconomic benefits such as an increase in business productivity, employment, and efficiency. Likewise, significant social benefits can be generated in spheres such as education, healthcare, access to information, and electronic government.

In spite of the socioeconomic benefits generated by the expansion of broadband in developing countries, the deployment of infrastructure to achieve such expansion in LAC presents economic barriers when it comes to reaching remote areas with low population density (Table 6).

The chief obstacles that have hampered the development of universal access have been, on the one hand, the high cost of the deployment of infrastructures and,

Table 6

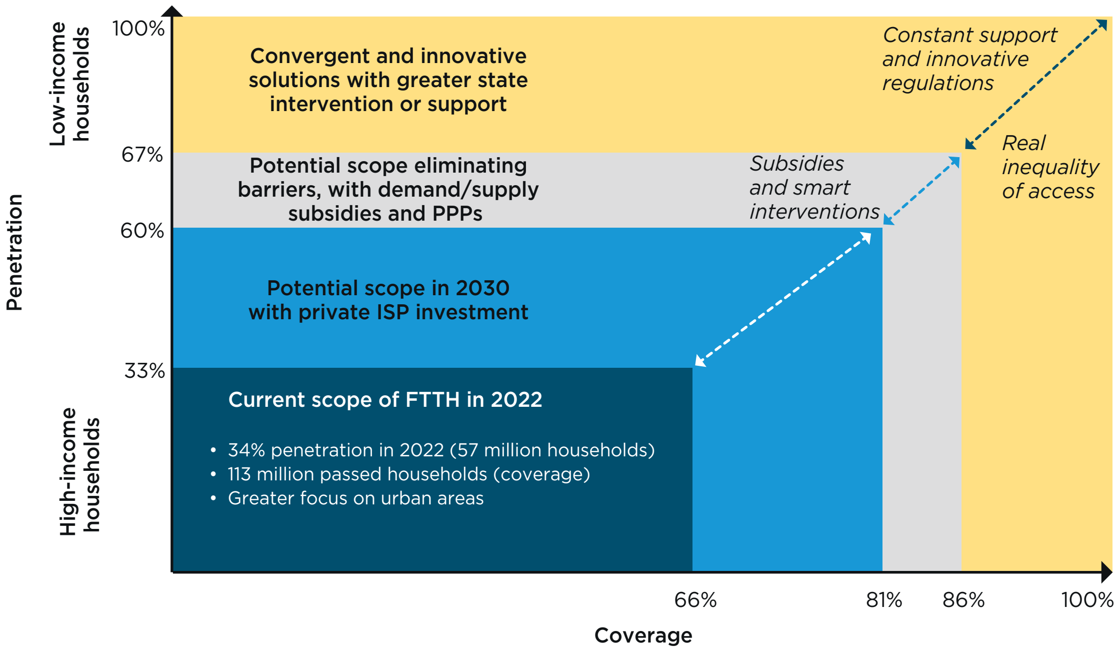
Barriers for the Development of Broadband Infrastructure in Areas of Low Population Density in LAC

Type of barrier	Brief description
Greater need for infrastructure	
Varied and sometimes inaccessible geography	The Amazon rainforest or small Caribbean islands Mountainous areas
Long distances between settlements	Significant concentration of the population in major cities Fragmentation of the rural population
Low demand	
Remote areas with low population density	90 percent of the land area in LAC corresponds to rural areas The rural population represents less than 20 percent of the total population in LAC
Downward trend in rural population	The share of rural population in the total population has been falling at an average annual rate of 1.4 percent (from 27 percent in 1995 to 19 percent in 2018)
Lower potential income	
Limited available income	ARPU significantly lower than in developed markets (76 percent lower) Affordability: the average price of broadband in LAC is more than 5 percent of the gross national income per capita (at the international level the objective is 2 percent)
Lower teledensity and digital skills	The populations of rural areas present lower intensity in the use of ICT services
Aging rural population	As a result of migratory movements towards urban centers, especially by younger people
Greater capital costs	
Higher weighted average cost of capital (WACC)	WACC for telecommunications services is greater in emerging markets. For example, Telefónica calculates a WACC of 6.2 percent in Spain and the United Kingdom and 4.9 percent in Germany, whereas in LAC the WACC is 10.0 percent in Brazil, 8.4 percent in Peru, and 22.0 percent in Argentina (see note below).
Lower earnings before interests, taxes, depreciation, and amortization (EBITDA)	LAC is the region with the lowest margin of EBITDA (15.2 pp below the average for developed markets) in the world.

Source: Authors' elaboration.
Note: In its annual consolidated report for 2019, Telefónica reports the discount rates—referenced to the local currency, after taxes—used in some of the markets in which it operates.

Figure 13

Household Coverage and Penetration of Fixed Broadband Applied to FTTH



Source: Authors' elaboration, based on infoDev and ITU (2009).

on the other, the limited profitability that these investments produce for operators. This converts rural, low-resource areas into an unattractive business for telecommunications firms. In this context, it is not feasible to expact that market development can by itself generate widespread availability of telecommunications services; rather, universal access will only be possible via a political-regulatory intervention that serves to alleviate market failures. This is shown in the Information for Development Program (infoDev) report of the World Bank and the International Telecommunications Union (ITU) (infoDev and ITU, 2009), which introduces the concept of inequality of access represented by three areas: market insufficiencies, smart subsidies, and real inequality of access (Figure 13).

To attract private sector interest in infrastructure deployments, a different level of involvement by the state is required. Figure 13 shows that, in the zone of the current scope of network and access, where there are good competitive conditions, the market can satisfy connectivity demand with a moderate or "light touch" policy-regulatory intervention, such as by promoting competition, service quality, and customer care, among others.

In the zone of market insufficiency, regulators and policymakers should eliminate non-economic barriers, formulate and apply enabling regulations by providing supply-side incentives, guarantee competition among all commercial actors, and generate a favorable fiscal, business, and investment climate that stimulates public-private agreements that are of social interest. This implies, at the same time, a smart subsidy that requires precise and measurable interventions, such as demand-side subsidies that ensure that sectors covered by the service can acquire it. The sustainability of these policies over time is crucial and their projection within the state budget must be appropriately planned and controlled with the aim of achieving the effect for which they were intended. The following section simulates some of these alternatives, which would help to extend coverage and narrow the gap of use or penetration.

Finally, in the zone in which there is real inequality of access, continuous financial support is required, alongside the exploration of innovative regulatory solutions (probably convergent and more flexible) to arouse interest in developing areas of such high commercial risk. In this case, the role of the state and the regulator must include a vision of the future and knowledge and exploration of the technological alternatives available, through segmented strategies that can address every type of unsatisfied demand encountered in their territories.

4

Efficient and Timely Deployment of Fiber Is Needed to Achieve Robust Connectivity

Deploying fiber optic in LAC will be necessary over the coming years to achieve the objectives regarding the adoption of FTTH/B and 5G, which support robust solutions that can give a much-needed boost to productivity in the region. Therefore, as well as having clear rules and conditions for deployment and coordination among the different actors, it will be fundamental to establish a supply chain able to sustain the observed growth in demand. This is of particular concern, especially since the COVID-19 pandemic and Russia's invasion of Ukraine, which have exposed diverse bottlenecks—such as increased delivery times and a lack of training for qualified personnel—that make development more complicated.

Among the factors currently causing greater scarcity in the supply chain are the lack of materials, the increased costs of materials and logistics services, and greater volatility and lower predictability in delivery times (given that the materials come mainly from Asia), among others.

How Is the Fiber Optic Supply Chain Structured?

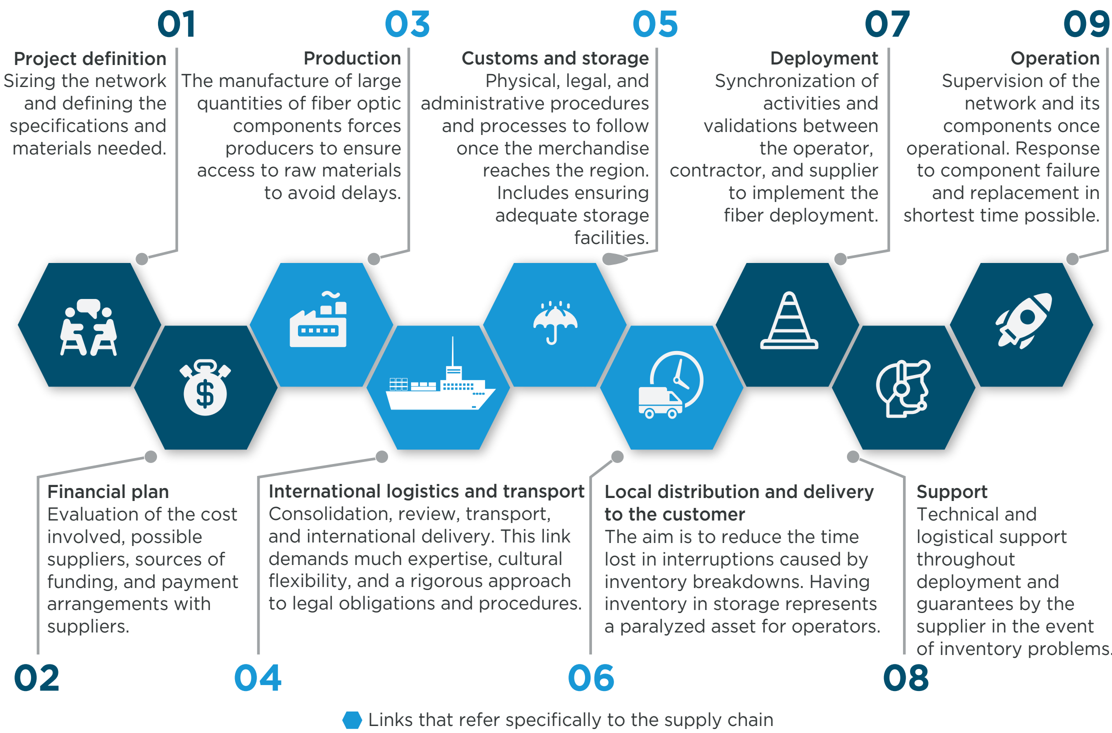
The fiber optic supply chain is composed of nine links that range from defining the project to operating a fiber optic network (FYCO and SmC+, 2022). Throughout the supply chain there are various considerations for any operator wishing to deploy fiber optical cable (Figure 14).

The nine links can be briefly described as follows:

1. **Project definition:** Includes all activities for sizing the network and defining the

Figure 14

The Fiber Optic Supply Chain



Source: FYCO and SmC+ (2022).

specifications and materials needed to deploy the fiber optic network.

2. **Financial plan:** An assessment is made of the implied cost, return on investment, possible suppliers, possible sources of financing to fund deployment, and possible payment arrangements with suppliers.
3. **Production:** In this phase large quantities of fiber optic components are manufactured. This link works in conjunction with the supply of necessary raw materials.
4. **International logistics and transport:** Includes consolidation, review, transport, and intercontinental delivery.
5. **Customs and storage:** Comprises all the physical, administrative, and legal procedures and processes necessary to ensure the merchandise reaches the region. Includes defining where the merchandise will be stored.
6. **Local distribution and delivery to the customer:** Represents the final purely logistical stage of the fiber supply chain, where distribution is made within LAC

to the final customer who will be implementing the fiber deployment.

7. **Deployment:** Refers to the synchronization of activities and different validations to be carried out between the operator, the contractor, and the supplier in order to deploy the fiber network.
8. **Support:** Includes all the technical and logistical support needed during deployment or in the event of inventory losses.
9. **Operation:** The final link deals with supervising the network and its different components while the network is operational. This link includes responding to component failures.

As can be observed in the links of the fiber optic supply chain, international transport activities, overseas trade, and clearing of merchandise through customs are especially important given that the supply for the region comes mainly from Asia.

Although the principal actors have different profiles, practically no players in the market offer a solution that covers all the links of the fiber optic supply chain in LAC (Figure 15).

Although production initiatives exist in the region, they are of limited significance with respect to their share in the supply of raw materials. They have, however, alleviated response times for component manufacture to some extent given that delivery can now take at least eight weeks or more. Nonetheless, the price of production in the region is, on average, 20 percent higher than that of Asian products, which is extremely relevant in a market whose decision-making criteria when it comes to fiber deployment is based more on price than on quality and local expertise.

Supply Chain Bottlenecks Can Affect Development in the Region's Countries

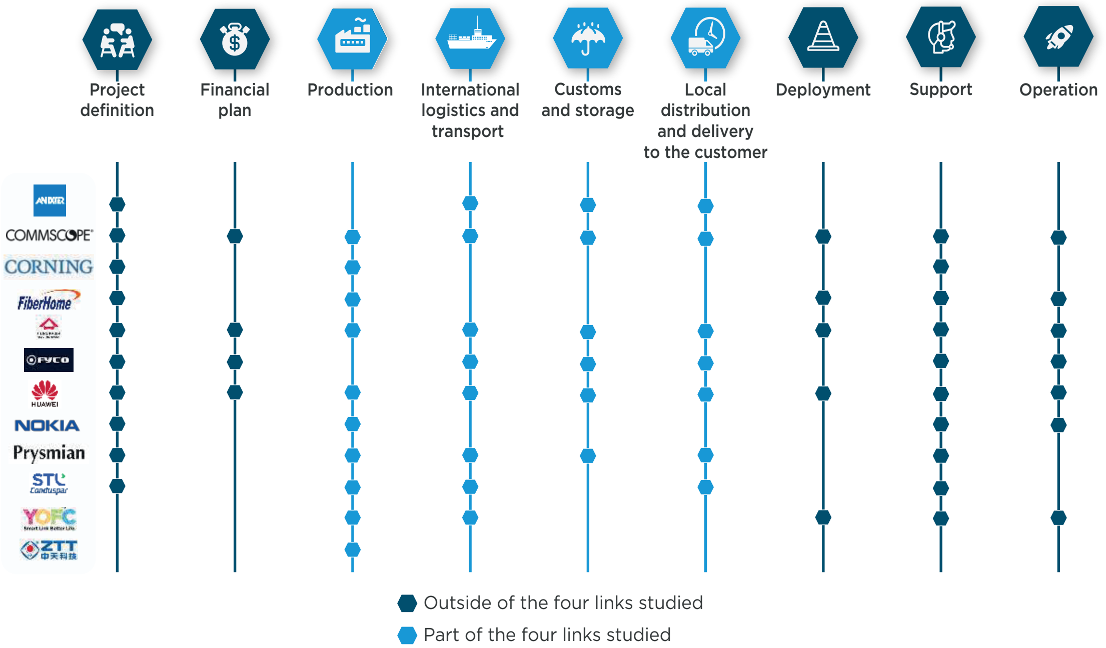
Fiber optic supply chain bottlenecks that are not anticipated and managed proactively can lead to delays in deployment due to suitable materials not being delivered on time. Lacking materials also can cause delays due to the reallocation of work teams to other areas, which may even delay restarting the work long after the materials have arrived.

Obtaining raw materials is one of the main bottlenecks faced. The following complications are the most common, among others:

- Scarcity of raw materials and components. Raw materials such as PVC, stainless steel, aramid, and neon fibers are increasingly difficult to obtain and delay manufacturing times (Bodine, 2021). Similarly, there are delays in the production of chips and semiconductors (Hardesty, 2021) and, although plastic and glass are not currently scarce, there are limited resources, especially of white sand, as the costs of extraction are expected to rise over the coming years.

Figure 15

Principal Actors Participating in the LAC Fiber Optic Supply Chain



Source: SmC+, based on public information about the firms.

- Change in competition and production conditions in Asia, mainly due to the COVID-19 pandemic.
- Prioritization of orders from customers in markets where manufacturers can achieve higher profit margins.
- Cultural differences that can lead to errors in understanding the agreed delivery times or even of the specifications of the materials.

Of the bottlenecks that relate most closely to the logistics of optical cable delivery, the following are worth mentioning:

- Significant increase in the costs of international transport, which are at present three times higher than they were prior to the COVID-19 pandemic.
- The lack of containers and the shipping backlog are affecting logistics. Following the pandemic, the demand for products exceeded the capacity for delivery, and there were also complications due to the poor global distribution of containers, with many remaining empty and stranded in different parts of the world. Sending containers from Asia to South America has a high impact, given that it

involves a long period of time in which a container is occupied and unavailable for shorter routes that could yield higher profitability.

- Increase of regulation in international trade from Asia, mainly from China.
- Disparity in customs clearance requirements and waiting times among the different countries of the region, for which specialist knowledge is required to avoid the merchandise becoming stranded dockside for long periods of time.
- Adequate distribution management in LAC. Given the continent's long distances, geographical features, and diverse customs requirements in different countries, among other obstacles, it is important to store materials in locations as near as possible to the deployment zone.

The lack of workers specifically trained in fiber optic installations is also worth highlighting. In general, network operators focus on internal training and on improving the skills of existing employees instead of relying on contractors. Of course, there are also more formal training programs (FBA, 2022). In LAC, the FBA LATAM[23] program has been established to tackle the lack of a technologically skilled workforce in the industry. The platform comprises training courses to obtain the FBA Expert certification, and its objective is to set the standards in knowledge and skills for the design, assembly, installation, operation, and activation of FTTx networks in the region.

A recent study by FYCO and SmC+ (2022) estimates that over the next five years 7.5 million kilometers of fiber optic cable will be needed in the region in order to roll out deployments of FTTH/B domestic networks, 5G infrastructure, and backbone deployments in each country. The study also estimated that the existing barriers could extendsupply delivery times in each link of the chain and lead to possible delays in the region of up to 30 percent of normal supply time.

To support current demand, proactively addressing the barriers and complexities to make optical cable available for deployments is fundamental. Delays of such magnitude would imply, for example, that deployments over the next five years could be slowed by up to 19 months solely due to delays in supply, which would affect both private and public sector actors (Figure 17).

The supply of fiber optic cable has fundamental implications for the provision of public services and to meet governments' increasingly frequent digital solutions. Bottlenecks could lead to significant economic costs for the region and delay people's access to the internet and to services that equalize opportunities for all citizens irrespective of their geographical location, education, or income levels.

[23] See FBA LATAM and the joint initiative it promotes with FYCO Learning at https://fiberbroadband.org/latam-committees/.

Box 4

The Rising Price of Fiber Optic Cable in Recent Months

From 2003 to 2021, the price of fiber optic cable saw a sustained decline of 24 percent.

Nonetheless, based on the United States producer price index (PPI) and, more specifically, prices relative to the manufacture of fiber optic cable, from 2021 onwards this trend changed and began to recover part of the price lost at an average annual rate of 14 percent. In the first six months of 2023, the price level was practically the same as it was in 2003.

The main explanations for this increase are some of the same issues addressed in this publication: (i) exponential increase of demand, (ii) scarcity of raw materials, and (iii) supply chain limitations.

Figure 16

U.S. Producer Price Index (PPI): Fiber Optic Cable Manufacture

Unit: December 2003 = 100.0

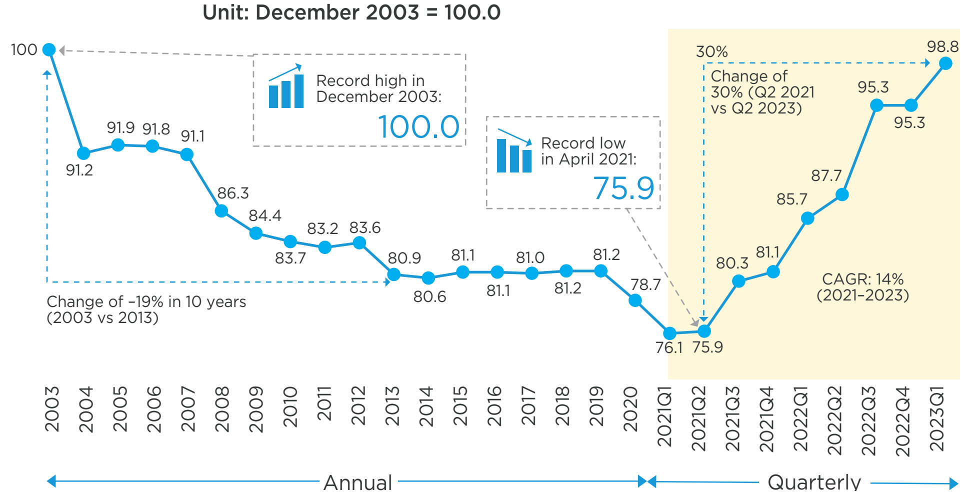
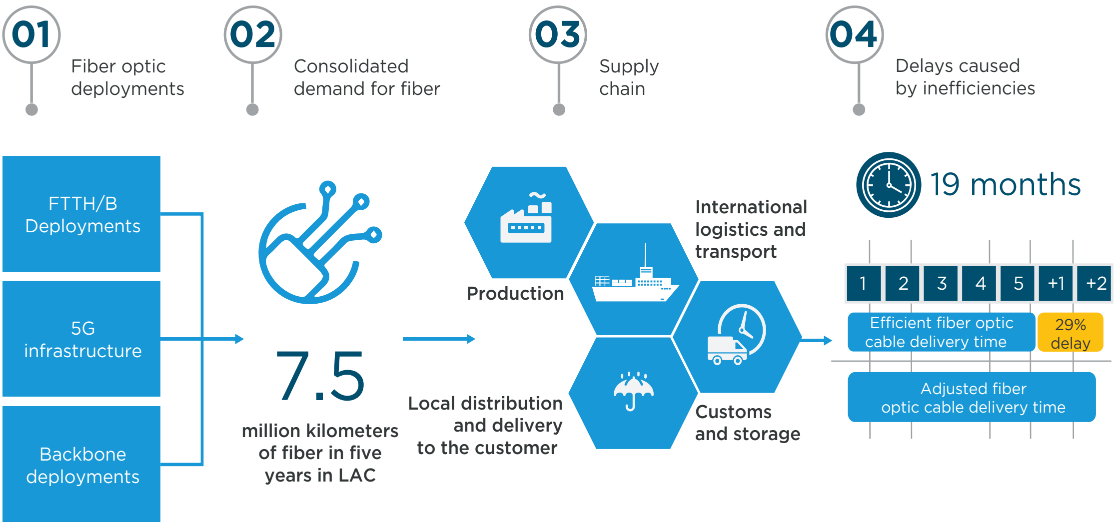


Figure 17

Estimated Impact of Fiber Supply Chain Inefficiencies in LAC



Source: FYCO and SmC+ (2022).

5

The Region Expects Investments in Fiber of More Than USD 130 Billion through 2030

The following section seeks to determine, based on observed growth trends and projections, the level of investment necessary in order to sustain such growth between the years 2023 and 2030 and thereby increase the region's level of broadband coverage. For this purpose, a model is presented here that parameterizes some of the costs and the type and speed of deployments observed in the different countries studied and also estimates and establishes relations to weigh the different investment components.

Conceptual Framework and Key Variables of Fiber Optic Investment Models

The estimation model developed and explained below focuses on the quantity of optical cable needed to reach the end users and provide connectivity services, rather than concentrating on deployment projects in backbone networks in LAC countries or the deployment of submarine cable. This is because the optical cable required for backbone (also called trunk) networks is often planned and deployed separately, with different considerations and projections. In many cases, there is already a highly developed backbone network infrastructure that interconnects different regions and service providers. Such infrastructure is often efficiently shared by various service operators, so it may not be necessary to consider the construction of new backbone networks to satisfy the end users' connectivity demands.

Backbone networks imply high-level infrastructure that connects different geographical areas or significant points of exchange, such as data centers or transmission stations. These networks are used to transport large volumes of data between main locations and, often, require greater transmission capacity. Planning and estimating the demand for fiber optic cable in backbone networks is generally based on different criteria, such as transport capacity, expected traffic, connectivity needs over the long term, and peering agreements, among others. Likewise, and for similar reasons, the demand for optical cable for undersea deployment is also excluded.

Therefore, the demand for basic fiber for end users can be defined as comprising the following stylized elements:

- **Household passed by FTTH:** Refers to the costs incurred in laying optical cable to the building.
- **Household connected with FTTH (or fiber drop):** Refers to all costs arising from connecting a subscriber in a passed household.
- **FTTA:** Refers to all the optical cable required to provide connectivity to the new mobile connectivity infrastructure that is expected in the coming years (macro and microcells), particularly following the advent of 5G technology.
- **Maintenance of fiber deployments:** These are the operational costs required to guarantee the performance, reliability, useful lifespan, and regulatory compliance of the fiber optic cables deployed.

In all cases, the totality of costs required for the deployment of fiber are considered—that is, the optical cable itself, all accessories for its installation, and the personnel who complete the infrastructure works (the latter represents approximately 60 percent of the total cost). In the case of fiber to the home, the costs related to the optic node terminal (ONT)[24] are considered, as well as customer premises equipment (CPE) costs,[25] which are often to be found in the same device.

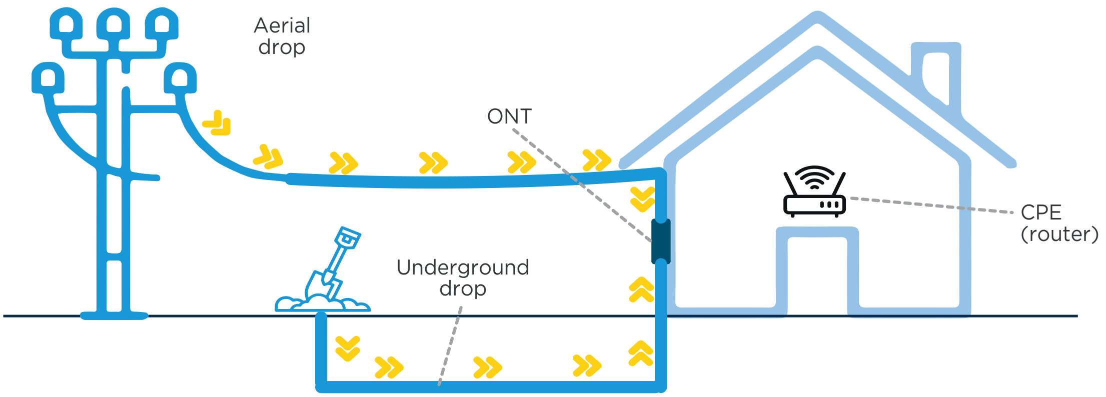
Figure 18 presents a simplified diagram of a fiber connection to a household, which shows the alternative possibilities of overhead or underground cables, the ONT, and the CPE.

[24] The ONT is a device utilized in fiber optic networks to connect the infrastructure of the fiber network with the devices of end users such as telephones, computers, or televisions. The ONT is located at the very end of the fiber network and acts as a point of interface between the fiber and the user's network devices. Its main function is to convert the optic signal transmitted via the fiber into electrical signals that can be used by the devices of the end users. As well as converting the signal, the ONT can offer other functionalities depending on the services provided via the fiber optic network. For example, it may include ethernet portals for connection to internet, telephone portals for telephone services, and television portals for internet protocol television (IPTV) or other multimedia services.

[25] In telecommunications, CPE refers to the equipment or device found in the installations of the customer or end user. The CPE acts as an interface between the service network provided by the service provider and the customer's devices in order to make use of communication services. Routers and modems (i.e., devices that allow customer devices such as computers, telephones, tablets, etc., to connect to the internet service network or local area networks) are examples of CPE.

Figure 18

Simplified Diagram of FTTH Connection



Source: Ziply Fiber.

To estimate the total amount of investment in LAC, 13 countries[26] were considered and from there an extrapolation was made to the current population in order to obtain the total value for the region.[27] Therefore, the estimate of the investment needed to achieve coverage of around 80 percent was determined based on expected deployments and their cost in each country depending on whether these were urban or rural areas and overhead or underground installations.

Level of Coverage: The Challenge in Remote and Rural Areas

Achieving average coverage in the region of around 80 percent of total households, both urban and rural, implies a major challenge given that the gap between those spaces is actually very significant. This goal means taking fiber and robust connectivity to its limit or possible limit in the next seven years. It is no small feat, given that making progress in the last sections of household coverage requires greater investments, whether in densely populated urban areas, such as informal settlements and popular neighborhoods, or places of low population density where the fiber optic profitability model quickly becomes indefensible. It is worth highlighting that there are countries in the

[26] Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Jamaica, Mexico, Panama, Paraguay, Peru, and Uruguay.

[27] According to information from the World Bank, in 2021 the total population of LAC rose to 655 million inhabitants, with the 13 countries considered in this paper totaling 544 million inhabitants. On this basis, the population of the remaining countries of the region corresponds to 17 percent of the total.

region, such as Argentina and Uruguay, in which 90 percent of households are urban, whereas other countries, such as Bolivia, Ecuador, Jamaica, Panama, and Paraguay, report 70 percent urban households. On average, 82 percent of the region's households are concentrated in urban areas.

Figure 19 shows the number of households and the proportion of urban households with respect to the total in the 13 countries considered.

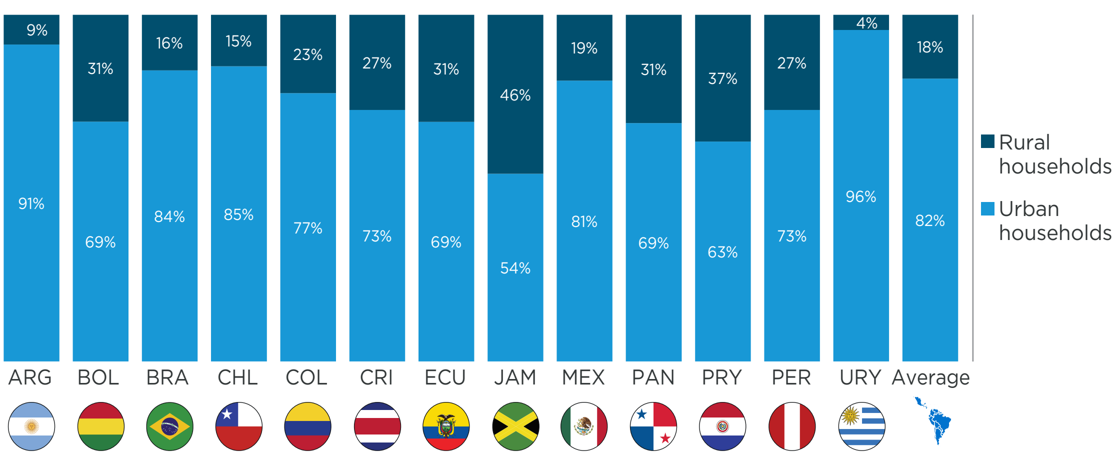
As part of this analysis, it is assumed that deployments in rural and remote areas get underway once coverage in urban areas has already reached two-thirds and, from that moment onwards, deployments are made in proportion to the number of households of each type. This is due to the fact that ISPs, as previously mentioned, always prioritize urban areas where the population density and purchasing power are greater and, therefore, the business is more attractive. For 2022, it was estimated that average coverage for the region is 66 percent of households (78 percent in urban areas and 15 percent in rural areas) and that, by 2030, it could reach its ceiling of 81 percent (93 percent in urban areas and 29 percent in rural areas) (Figure 20).

As observed in Figure 20, the difference between the number of passed households in rural and urban areas is significant. This difference is produced by the number of households in one or the other typology (82 percent are urban) and by the greater commercial attractiveness of urban households.

It is worth highlighting that the gap in passed households between urban and rural areas is around 60 pp, and sometimes even higher. Reducing this gap and thereby pro-

Figure 19

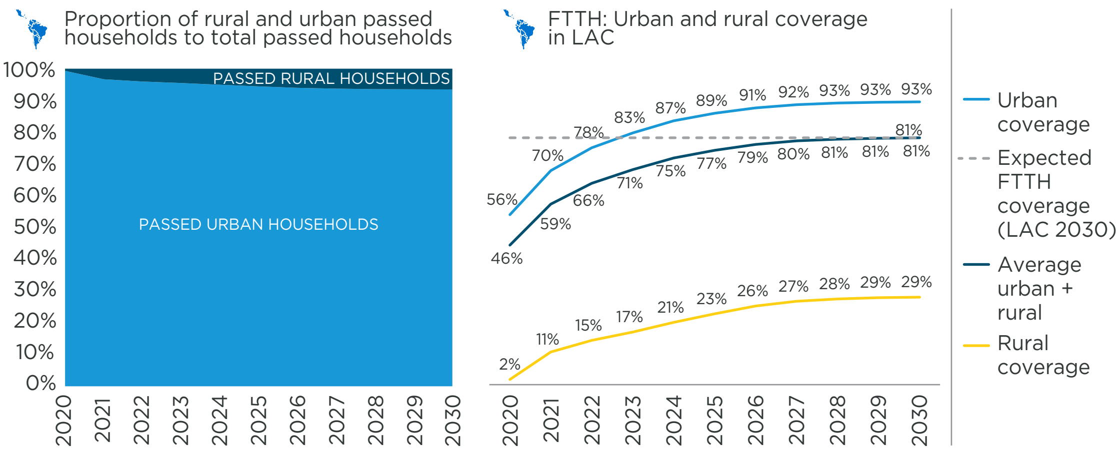
Proportion of Urban Households in LAC



Source: Authors' elaboration, based on information from the World Bank and the national statistics institutes of the countries surveyed.

Figure 20

Deployments and Coverage in Urban and Rural Areas



Source: Authors' elaboration.

viding greater coverage to remote and rural areas is one of the major challenges facing the region, to which must be added increasing access or subscribers. On the one hand, narrowing the coverage gap requires significant investments given that deployments in these areas are significantly greater than those in urban areas. Furthermore, increasing take-up and maximizing access requires efforts to stimulate demand—through subsidies or competitive prices to improve affordability or skills development—in the event that this were a limiting factor.

Overlapping Deployments: More Than One Operator for Each Passed Household

"Overlapping deployments" in FTTH refers to the situation in which various ISPs install their fiber optic networks in the same area.

Overlapping deployments mainly happen in urban areas and in those with greater purchasing power (see Table 7), where business and economic attractiveness awake interest from more than one internet provider. The economic analysis indicates that, despite the level of competition, the potential income can be sufficient to cover the initial investments and the operating costs, and that a return on investment can thereby be obtained in line with corporate objectives. Each ISP installs its own fiber optic network, using fiber optic cables that extend from the base stations to the users' households.

As expected, overlapping in remote or rural areas is almost nonexistent, with limited exceptions, which means that whenever there is the option to connect to a fiber-based broadband service, it is usually a single firm that provides the service.

Table 7

Overlapping Fiber Deployments in Urban Centers

Country	2022		2030
ARG	1.25		2.80
BOL	1.00		1.41
BRA	1.62		2.80
CHL	2.20		2.80
COL	1.14		1.90
CRI	1.05		2.32
ECU	1.03		1.70
JAM	1.01		1.62
MEX	1.48		2.80
PAN	1.01		2.49
PRY	1.06		1.68
PER	1.05		1.78
URY	1.00		1.80

Source: Authors' elaboration.

Overlapping deployments of FTTH in cities have various benefits for consumers. Overlapping provides greater competition among ISPs, which can lead to an improvement in internet service prices and quality and accelerate the adoption of high-speed broadband in a city. With multiple ISPs competing for customers, there is an incentive to constantly improve network quality and offer faster connection speeds.

Nonetheless, overlapping fiber deployments also accentuate the challenges faced by infrastructure deployments, given that careful coordination is required between the different ISPs and the local authorities to avoid problems of congestion or interference between networks. Moreover, overlapping networks can lead to greater complexity in terms of infrastructure management and maintenance.

Underground and Overhead Optical Cable

The installation of underground fiber optic implies a process that includes the following steps: (i) planning and design; (ii) preparation of the terrain, which includes digging trenches or opening up underground channels; (iii) placing conduits in the trenches or underground channels to protect and house the optical cables; (iv) fiber optic cable blowing, which involves blowing the glass fiber through the ducting; (v) connections and terminations; and (vi) testing and verification.

The process of overhead installation involves different steps: (i) planning and design; (ii) evaluation of existing support structures, such as those pertaining to telecommunications or electricity companies, or public utilities in general; (iii) preparation of the cable; (iv) installation of the support structures needed along the installation route (e.g., hooks, clamps, or brackets designed specifically to safely hold fiber optic cables in place); (v) installing the cable, which can be done through a new connection to a post or by using a technique known as overlapping, which involves connecting new cable to existing cable; (vi) securing the installation and additional protection, which can include the use of dampers, circuit breakers, and additional protective optical cable coating; (vii) connections and terminations; and (viii) testing and verification.

It is obvious that the participation of specialized personnel, such as engineers and fiber optic technicians, will be required for both overhead and underground deployments. Moreover, the processes and techniques employed can vary depending on the specific requirements of the project and local regulations. It is therefore recommended to rely on qualified professionals and follow the best practices for fiber optic installation.

It is expected, and the model of estimation confirms, that underground installations are more common than overhead deployments in the region and especially in urban areas.

Costs of Deployments

The cost of a passed household depends mainly on the density of households in the region: the greater the density, the lower the cost, and vice versa. The FBA and Cartesian, a specialist consultancy firm, conducted a study in the United States regarding the cost of constructing an FTTH network according to the density of households per square mile (FBA and Cartesian, 2019) (Figure 21). The study reported the following spread of costs for urban and rural areas in the United States (see Figure 21):

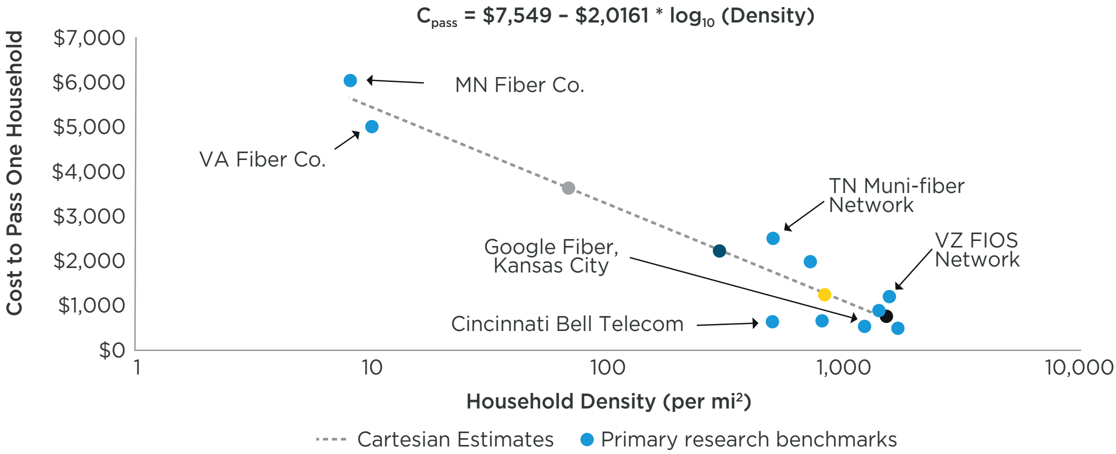
- Urban: USD 700 to USD 1,500 per passed household
- Rural: USD 3,000 to USD 6,000 per passed household

Thereby, based on the population density in urban and rural areas of the LAC countries considered, the cost of deployment per passed household in the United States was estimated, and this value was thereafter converted for each one of the LAC countries using the purchasing power parity (PPP)[28] of the International Monetary

[28] The PPP represents the amount of currency in a country of reference needed to acquire a basket of goods and services that is equivalent in both economies. Therefore, these are rates that can be converted into common currency, allowing the purchasing power to be assessed equally.

Figure 21

Cost of Deployment for One Passed Household



Source: FBA and Cartesian (2019).

Fund (IMF).[29] Based on the same study, a 17 percent lower cost was assumed for overhead deployments.

The fiber connection process converts any households that *can* be connected to fiber into households that *are* connected to fiber in order to access high-speed voice, video, and internet services. In other words, it is the conversion of a passed household to a connected household (a fiber optic cable drop from the nearest point of access to the network connected to the household, which enables a customer to request and receive internet and voice services from their fiber provider). The average cost of connecting a household in the United States is between USD 500 and USD 700 and, for the purposes of this publication, a cost of USD 600 (Kim, 2022) was considered. As in the case of the cost for each passed household, this amount was thereafter converted to each one of the countries by calculating the PPP.

Finally, with regard to FTTA installations, the projection of micro and macro cells in a study carried out by SmC+ for American Tower (Cabello, Ros Rooney, and Fernández, 2021) was taken as a basis. Thereafter, using these estimates and examining different cases at the international level, the number of meters of optical cable required for a macro cell and a micro cell in urban and rural contexts was estimated. Then, based on the number of kilometers to be deployed in a country and the total cost of deploy-

[29] The IMF's Implied PPP Conversion Rate of the World Economic Outlook is available at https://www.imf.org/external/datamapper/PPPEX@WEO/OEMDC.

ment per unit of length, the investment required in each country was estimated. The total cost of deployment per kilometer was arrived at by considering the cost of Colombia's National Fiber Optic Project (Proyecto Nacional de Fibra Óptica) (MinTIC, 2019), converted for each country by calculating the PPP as can be seen in Table 8.

Table 9 shows the costs of deployment for each of the 13 countries considered in the analysis.

Table 8

Fiber Optic Cable Requirements for FTTA Deployments (in meters)

	Urban	Rural
Macro cell	830	8,170
Micro cell	250	N/A

Source: Authors' elaboration.

Maintenance of Fiber Deployments

It must be remembered that in addition to the investments required for fiber deployments, the industry must subsequently shoulder the maintenance costs of such networks—costs that will grow over time insofar as the fiber networks become more extensive and older.

The cost of maintaining fiber optic installations depends on factors such as the complexity of the equipment, the environment in which it is deployed, quality of the materials, age of the system, technical capacities of the personnel, and availability of spare parts and replacements, among other variables.

Keeping in mind the fiber optic installation maintenance costs is essential for guaranteeing its performance, reliability, useful life, and regulatory compliance. Adequate maintenance helps to prevent failures, minimizes downtime, and maximizes the return on investment made in fiber optic infrastructure.

Fiber optic maintenance activities, both preventive and corrective, can be grouped as follows:

- **Surveillance:** To verify the condition of the network element, both by reporting degradation of the network element before the fault happens and reporting anomalies in the network element should they occur.
- **Testing:** To measure the specificities of the network element and confirm that they reach the required level.
- **Control:** To reestablish the network element to its normal state or take measures to maintain service quality.

According to an FBA (2020) study, the annual maintenance cost of an FTTH connection in the United States is around USD 53. If this value is taken and converted to reflect the reality of each country using PPP and then compared with the average cost of deployment in each country, the annual maintenance cost is

Table 9

Costs of Fiber Deployment (in USD)

	FTTH: passed household			FTTH: connected household	FTTA		Maintenance
Country	Urban: overhead	Urban: underground	Rural	Drop	Urban/rural: macro cell	Urban: micro cell	Percentage of investment
ARG	270	317	2.313	231	11,483	9,777	1.3%
BOL	256	301	2.017	219	10,888	9,271	1.2%
BRA	351	412	2.781	301	14,919	12,703	1.5%
CHL	378	444	2.993	324	16,086	13,697	1.5%
COL	249	292	1.658	213	10,586	9,013	1.7%
CRI	369	433	2.046	316	15,696	13,365	2.3%
ECU	351	413	1.824	301	14,950	12,730	2.0%
JAM	343	403	1.472	294	14,614	12,443	3.7%
MEX	341	401	2.090	293	14,529	12,371	1.9%
PAN	312	366	1.744	267	13,252	11,284	1.9%
PRY	271	318	1.902	232	11,511	9,801	1.3%
PER	321	377	2.307	275	13,661	11,632	1.5%
URY	515	604	4.410	441	21,891	18,640	1.4%

Source: Authors' elaboration.

found to be within a range of 1–4 percent of the investment, although in most cases the cost is between 1.5 percent and 2.0 percent.

For the purposes of this publication, only the maintenance costs of new fiber optic infrastructure to be deployed from 2023 onwards are considered.

Investment Required by Country and by Type of Deployment to Achieve 81 Percent Coverage by 2030

Based on the individual country values, the investment required for the period 2023–2030 for the entire LAC region can be estimated at around USD 134 billion (see Figure 22). This is the amount necessary to cover or achieve the proposed objectives of passed households, of connected households or buildings, and of FTTA for the provision of mobile services, as well as the outlays required for the maintenance of such deployments. Considered at current values, it is estimated that nearly 80 percent of said investment will go towards providing continued growth in the number of households passed and increasing coverage. Fiber required for the subsequent final connection to households represents nearly 12 percent of total investment and 4 percent corresponds to FTTA for the provision of 5G mobile services; the rest would cover the maintenance of these deployments.

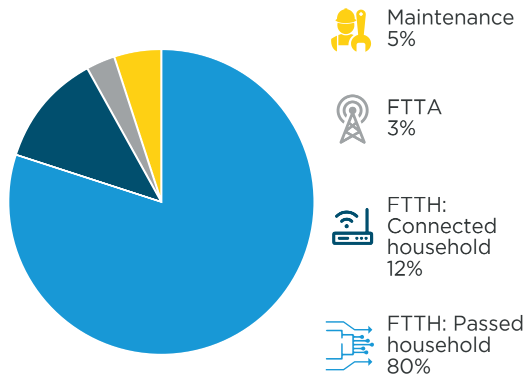
With regard to the investment per country, the cases of Brazil and Mexico stand out: combined, they represent 44 percent of the total regional investment (26 percent and 18 percent, respectively) as shown in Figure 23.

With regard to the right moment to make these investments, a relatively constant distribution is expected over time. Such continuity of the investments required is a consequence of the following considerations:

- Households passed: even if coverage flattens out, there is expected to be an increase in overlapping deployments, chiefly in the urban areas.
- The fall in the rhythm of new subscribers and reduced need for the deployment of FTTA for mobile connectivity is offset by the incremental cost of maintaining existing fiber deployments.

Figure 22

Total LAC Investment in Fiber 2023–2030, by Type of Deployment



Total investment 2023–2030 to reach regional FTTH coverage of 81% (current USD): USD 134 billion

Source: Authors' elaboration.

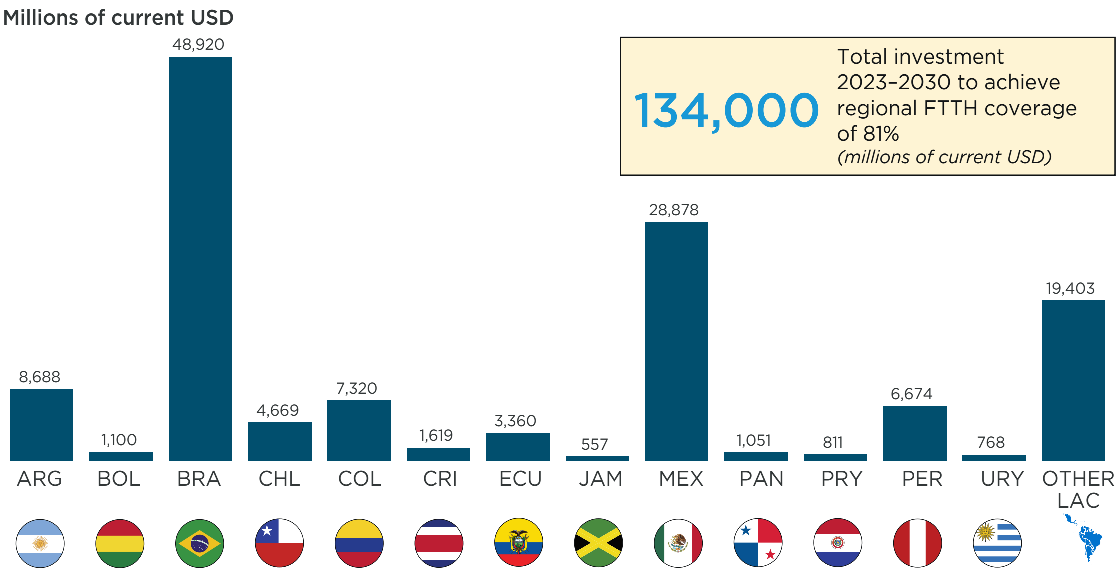
As Figure 24 shows, it is noticeable that, throughout the period, the investment level stays at an annual average value of around USD 17 billion for the entire region. It is worth highlighting that these amounts include both the requirements of the initial fiber deployments and their corresponding maintenance and/or replacement in the following years.

What Happens in the Case of the Most Ambitious Coverage Objectives?

For a region such as LAC, which has high geographical variety and income inequalities, reaching 100 percent coverage of super-fast broadband of 100 Mbps—as proposed, for example, by Spain's connectivity and digital

Figure 23

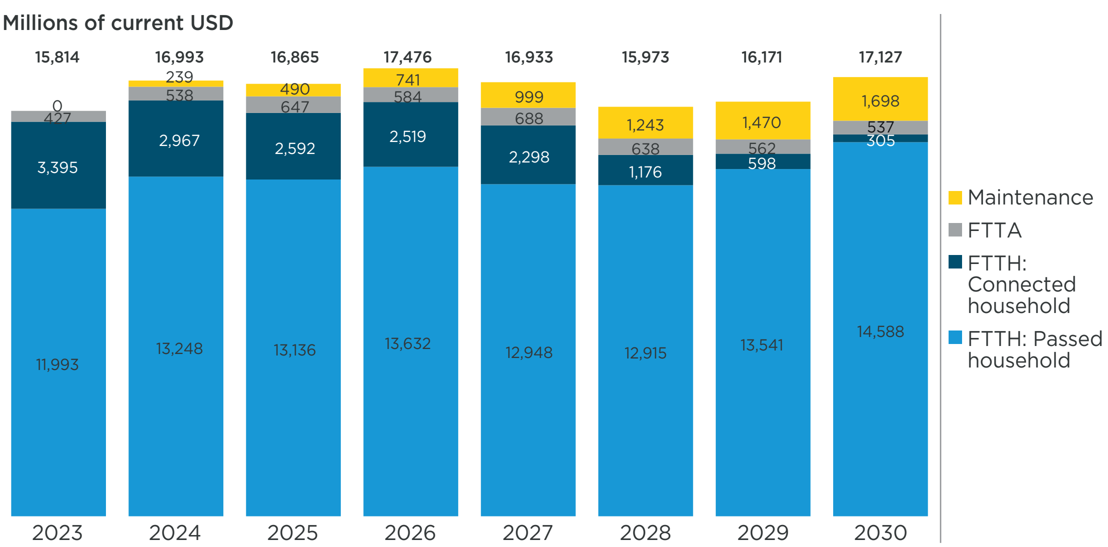
Investment in Fiber 2023–2030, by Country



Source: Authors' elaboration.

Figure 24

Annual Expected Investment in the Deployment of Fiber in LAC



Source: Authors' elaboration.

infrastructure plan for 2025[30]—would represent a very stiff challenge.

Surpassing the 81 percent ceiling of expected FTTH coverage for the region by 2030, in which 82 percent of households are urban (according to the average of the selected countries), implies reaching extremely remote or inaccessible territories, bringing extremely high costs that explode exponentially when connecting up low-density settlements.

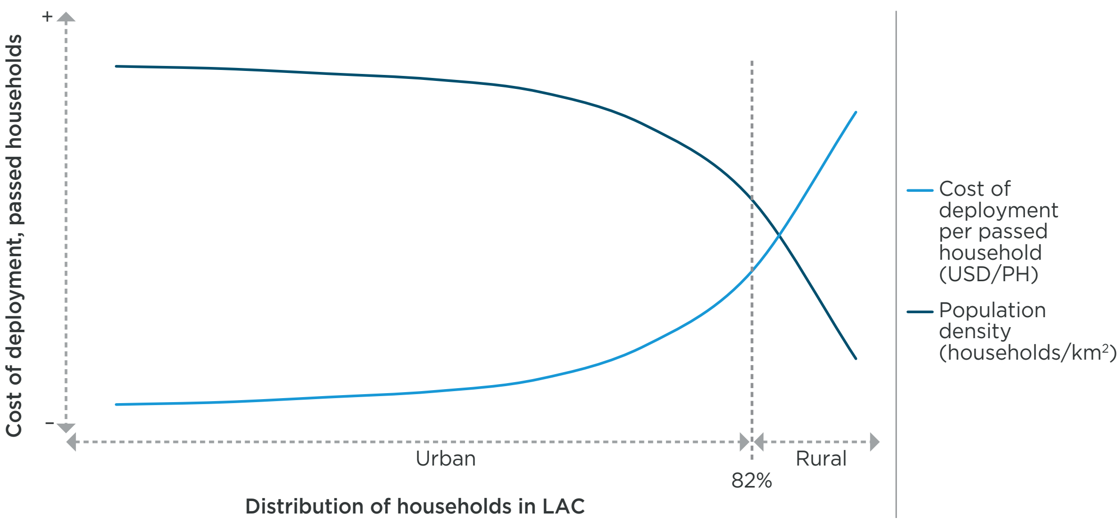
Given that urban coverage will already be achieving, on average at the regional level, 93 percent (except in some countries), the major increases in coverage must therefore happen in rural and remote areas, where deployments have a greater cost and lower commercial attractiveness.

Even when, for modeling purposes, moderate values have been assumed for the cost of the deployments in urban and rural areas, in practice their cost depends in each case on the population density of any given zone. In this way, the average cost per passed household continually rises insofar as higher levels of coverage are achieved, given that deployments in remote or rural areas begin to acquire greater significance. By way of illustration, Figure 25 shows how the cost of deployment increases significantly with lower population density.

[30] The Plan for Connectivity and Digital Infrastructure (Plan para la Conectividad y las Infraestructuras Digitales) of Spain's Ministry of Economic Affairs and Digital Transformation (Ministerio de Asuntos Económicos y Transformación Digital) can be found at https://portal.mineco.gob.es/es-es/digitalizacionIA/paginas/plan-conectividad.aspx.

Figure 25

Additional Cost of Deployments with Lower Population Density



Source: Authors' elaboration.

Increasing coverage and growing the number of subscribers in passed households is a challenge that requires introducing stimuli and policies with this aim in mind. The promotion of sharing, coordination, and incentives for different actors to deploy and invest in networks could lead to a leap forward with regard to the expected "normal" trend predicted for the region. To the same extent, increasing subscribers in passed households means designing policies that act to stimulate demand and that tackle the different gaps in affordability, skills, and relevant local content.

To address affordability, competition and the presence of overlapping networks will be determining factors that ensure that the price and quality of the services offered are within the available income thresholds of families. Further one-off or "smart" interventions could be in the form of subsidies that target the unsatisfied demand. Finally, education and training programs in connectivity skills and uses can be utilized to stimulate demand and usage and to improve the productivity of the self-employed, independent professionals, and small business owners, whose activities could benefit from superfast connections.

Table 10 presents two scenarios for different levels of coverage: the base scenario, in which coverage by 2030 reaches 81 percent, and a scenario of greater investments, coordination, and PPPs that would enable a regional average coverage of 86 percent to be reached. To define this higher coverage scenario, the following criteria were used, by country and for urban and rural areas:

Urban areas:

- If the coverage in 2030 is lower than 70 percent: +15 pp in 2030
- If the coverage in 2030 is lower than 80 percent: +10 pp in 2030
- If the coverage in 2030 is lower than 90 percent: +5 pp in 2030

Rural areas:

- If the coverage in 2030 is lower than 20 percent: +25 pp in 2030
- If the coverage in 2030 is lower than 30 percent: +20 pp in 2030
- If the coverage in 2030 is lower than 40 percent: +15 pp in 2030

Based on such an increase in coverage, the new amount of investment required—with active policies and a more encouraging environment for PPPs—can be calculated.

For the 13 countries selected, the difference of USD 21.5 billion (or 19 percent) between the investment required for 81 percent coverage and for coverage of 86 percent presents a significant challenge with regard to funding and its sources. To achieve such coverage, the private sector will not find an attractive business case, which means that governments must seek the tools needed to promote and achieve these deployments through strategies that subsidize either the demand or the supply side. The other LAC countries are not included in this detailed calculation given that the number of households or their urban/rural distribution has yet to be fully revealed, meaning that the extrapolation of investment is made using a linear projection of their population.

Table 10

Sensitivity Analysis: Greater Investment for Greater Coverage

	BASE CASE					CASE WITH GREATER COVERAGE					DIFFERENCES				
	Urban coverage 2030	Rural coverage 2030	Total coverage 2030	Connected households (in thousands)	Investment (billions USD)	Urban coverage 2030	Rural coverage 2030	Total coverage 2030	Connected households (in thousands)	Investment (billions USD)	Urban coverage 2030	Rural coverage 2030	Total coverage 2030	Connected households (in thousands)	Investment
ARG	71%	4%	65%	2,350	8.7	81%	29%	76%	4,360	11.7	10 pp	25 pp	11 pp	2,010	34%
BOL	80%	13%	59%	766	1.1	90%	38%	74%	1,298	1.9	10 pp	25 pp	15 pp	532	73%
BRA	99%	33%	89%	6,285	48.9	99%	48%	91%	7,924	56.5	0 pp	15 pp	2 pp	1,639	16%
CHL	100%	64%	95%	791	4.7	100%	64%	95%	791	4.9	0 pp	0 pp	0 pp	0	4%
COL	82%	16%	67%	5,436	7.3	87%	41%	77%	7,089	10.0	5 pp	25 pp	10 pp	1,653	37%
CRI	86%	20%	68%	362	1.6	92%	45%	79%	543	2.1	6 pp	25 pp	11 pp	181	31%
ECU	100%	44%	83%	1,109	3.4	100%	44%	83%	1,109	3.5	0 pp	0 pp	0 pp	0	3%
JAM	100%	63%	83%	85	0.6	100%	63%	83%	85	0.6	0 pp	0 pp	0 pp	0	0%
MEX	99%	32%	86%	4,822	28.9	99%	47%	89%	5,825	32.5	0 pp	15 pp	3 pp	1,003	12%
PAN	92%	25%	71%	296	1.1	92%	45%	78%	368	1.2	0 pp	20 pp	7 pp	72	9%
PRY	96%	30%	72%	252	0.8	96%	50%	79%	394	1.2	0 pp	20 pp	7 pp	142	50%
PER	86%	19%	68%	2,902	6.7	91%	44%	78%	3,961	9.1	5 pp	25 pp	10 pp	1,059	36%
URY	98%	31%	95%	78	0.8	98%	46%	96%	86	0.9	0 pp	15 pp	1 pp	8	13%
LAC-13	**93%**	**29%**	**81%**	**25,535**	**114.4**	**95%**	**46%**	**86%**	**33,834**	**135.9**	**2 pp**	**17 pp**	**5 pp**	**8,299**	**19%**

Source: Authors' elaboration.

Furthermore, greater coverage also brings a more-than-proportional increase in penetration, which would enable an additional 10 million households to be connected, reaching a total of 113 million households. Through use of these selective smart stimuli, the elimination of barriers, and greater development of PPPs, household penetration could be boosted from 60 percent to 67 percent. In urban areas, this would happen as a consequence of more intense competition and improvement in prices and service quality, among others. In rural areas, a similar impact on penetration would emerge as a result of the greater affordability generated by selective demand subsidies, which are estimated to represent a cost of USD 1 billion for governments.

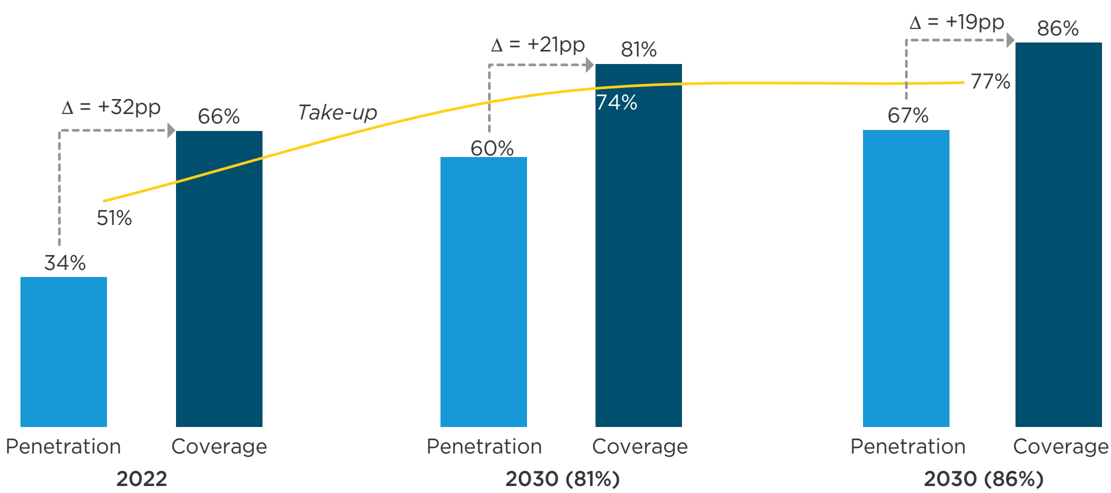
This increase in both coverage and penetration is also reflected in the take-up, which would rise from 74 percent to 77 percent, thanks to the demand stimuli from both the private sector (greater competition with overlapping networks) and from the state (incentives, education, and subsidies).

Figure 26 presents the situation in the region in 2022 with regard to penetration and coverage and the hypothetical situation in 2030 according to the two scenarios analyzed.

As can be seen, in 2022 the gap between penetration and coverage was 32 pp. Following new deployments and greater competition and affordability, in urban and rural areas respectively, this gap is expected to close. In the scenarios analyzed, by the year 2030 the gap would reduce to 21 pp

Figure 26

Evolution of Coverage, Household Penetration, and Take-Up in LAC in the Two Scenarios Analyzed



Source: Authors' elaboration.
Note: The "81%" and "86%" refer to possible coverage scenarios in the region by 2023.

in the case of 81 percent coverage, and to 19 pp in the case of 86 percent coverage. All this would imply a total investment of USD 160 billion (+USD 26 billion above that, which the industry would provide if the natural trend were followed).

6

Towards a Public-Private Collaborative Agenda at the Regional Level to Maximize the Scope of Robust Connectivity

How Can the "Big Moment of Fiber" Be Extended So That It Can Reach More Latin Americans?

As described throughout this paper, the region is growing significantly in terms of fiber deployments, meaning that household coverage has now reached, on average, 66 percent of households and is expected to reach a ceiling of 81 percent by 2030. This achievement will be reached in part due to the investment efforts of all participants in providing connectivity services, both public and private, who will need to invest around USD 134 billion.

Coverage will start to flatten out from 2026 onwards, when the peak of growth is expected to occur; thereafter, efforts must be focused on accelerating take-up—which implies maximizing household penetration or increasing subscribers—in order to fully capitalize on the deployment and investments made (and that are reflected in coverage or the number of passed households).

To be able to grow the number of subscribers, demand subsidies should be offered for the lower-income sectors or special plans put forward to narrow the penetration gap.

With the aim of extending coverage—that is, increasing the number of passed households beyond what would be the natural level for the industry—coordination among both private and public actors must be advanced, through both regulations or specific incentives as well as through the leadership of the municipalities themselves to facilitate, for example, rights of way with limited bureaucracy and a dig-once policy that rewards those who participate. Reducing the existing barriers described in the previous section will also be a crucial element for facilitating investments still further and making areas with a less-than-convincing business case more profitable.

Likewise, financing schemes implemented through PPPs could help to push the barrier of unprofitable passed households by making them profitable. If demand subsidies—which would make connectivity plans more affordable for lower-income sectors—were added to the equation, penetration could be advanced to nearly 100 percent of passed households.[31] In this way market insufficiency could be reduced by smart interventions and subsidies, such as those shown in Figure 27. A total of 113 million connected households could be achieved, including 10 million additional households in low-income areas where the business case for overlapping networks is unclear, but that would thereby gain access based on one-off stimuli and subsidies. Coverage will increase less than proportionally, as part of the investment may flow to areas already covered.

The following are some of the internal and external factors classified into opportunities, challenges, and barriers. The demand for data and the new uses of technologies, added to the efficiency of cost amortization and the long-lasting nature of fiber, are an opportunity that the market is clearly capitalizing and must continue to exploit.

A further opportunity that is materializing in the region, following the beginning of the allocation of 5G spectrum frequencies and their subsequent deployments, is the need to install FTTA. Due to the greater densification of networks than in previous technologies, this need is much more pressing for 5G than it was in the past for 3G or 4G.

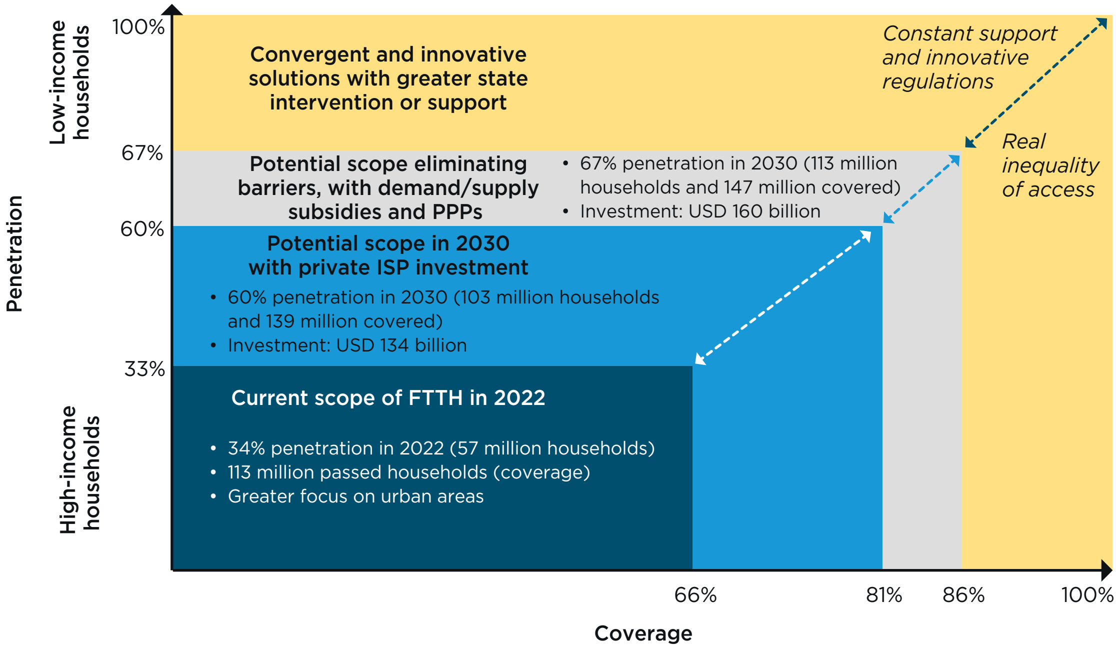
Among the challenges will be to continue growing with greater public-private coordination and collaboration, if growth is to be achieved beyond expectations. The simulation carried out for this paper shows that an effort to increase coverage with overlapping networks and demand subsidies can lead to penetration of 67 percent and coverage of 86 percent. Such efforts imply investments of USD 159 billion in deployments and, at least, USD 1 billion in demand subsidies.

With the aim of helping to reduce the use/affordability gap, this demand subsidy is calculated per year progressively from 2028 to 2030 (once the coverage ceiling has been reached) for a total of USD 1 billion, to which are added the investments yet to be made, which gives a grand total of USD 160 billion.

[31] It is important to remember that a penetration of 100 percent of passed households (or a 100 percent take-up) does not imply that all deployments carried out have an active subscription given that, especially in urban centers, there is expected to be an increase in overlapping in the most densely populated and higher-income areas. Therefore, a household might be passed by two, three, or more ISPs but have a subscription with only one of them.

Figure 27

Illustrative Diagram of Spaces of Coverage and Penetration of Fixed Broadband Applied to FTTH, with Investment and Households Reached



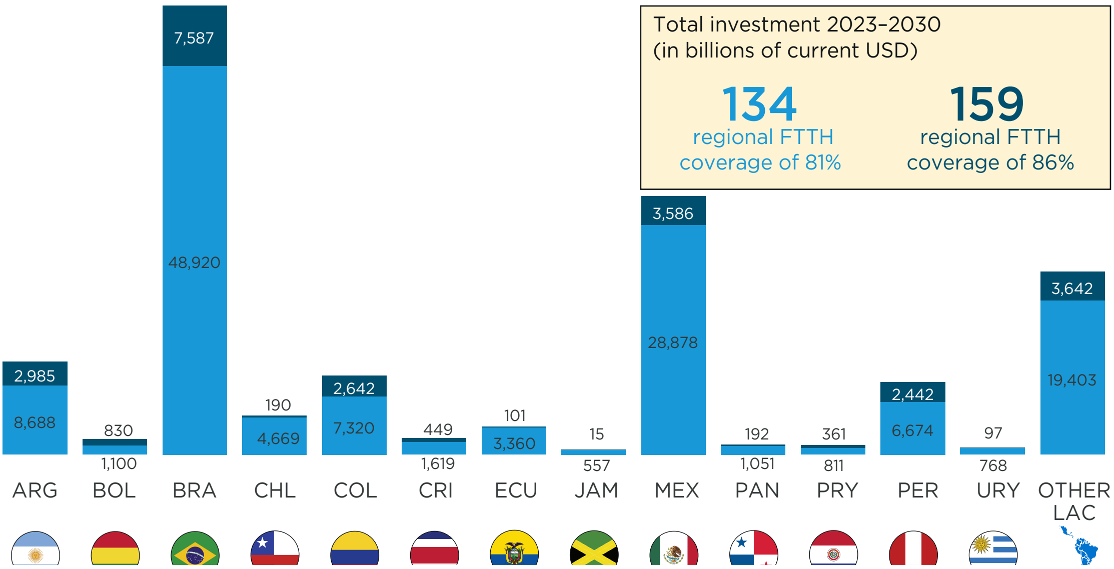
Source: SmC+, based on infoDev and ITU (2009).

The fiber optic industry, particularly in LAC, is coming under pressure due to the inefficiency of its supply chain, which has suffered stress in the context of growing demand, increased prices in the last two years, the crisis of international logistics, and suppliers, mainly from Asia, that often prioritize customers in other regions rather than LAC due to concern over profit margins. These inefficiencies and challenges in the fiber supply chain could lead to interruptions and delays in the expected deployments.

Vandalism is another increasingly prevalent challenge in the industry given that it results in service interruptions that can demand several hours' work before service can be resumed and higher network operating costs overall. These acts affect not only the telecommunications service providers (both in their fixed and mobile networks) but also the end users that depend on these services in their daily lives for access to internet, telephone, and television. To address this problem, telecommunications service providers often implement additional security measures, such as installing surveillance cameras in key points of the fiber optic networks and collaborating

Figure 28

Investment in Fiber 2023–2030, by Country for Both Coverage Scenarios



Source: Authors' elaboration.

with local authorities to prevent and combat vandalism.

One challenge that is not currently significant but is expected to gain relevance over the coming years is environmental sustainability. There are still no clear definitions or policies regarding the replacement of fiber optic installations nor the increased waste they will generate (see Box 5 for this and other determining factors for the growth of FTTH).

The barriers are currently being tackled, but they require special attention to ensure that they do not impede the sustained growth of fiber. One of the main barriers is linked to the economic appraisal that ISPs make in markets with low ARPU, high hard currency costs, and unstable local currencies. These conditions discourage investments and cause operators to exploit legacy technology to the maximum, as in networks of hybrid fiber-coaxial (HFC) and Data Over Cable Service Interface Specification (DOCSIS) networks.

The lack of qualified personnel for deployments and a relatively low availability of training can hamper deployments.

Finally, for many users, the performance of 4G/5G wireless access may be sufficient for their usage requirements, which could prevent the penetration of fiber from achieving its maximum potential.

Box 5

Determining External and Internal Factors for Expanding the Scope of FTTH

Opportunities		Challenges		Barriers	
Demand of data	New technologies demand more data use and traffic and robust low-latency connections	Environmental sustainability	There are no clear definitions or policies regarding duration and replacement	Lack of qualified personnel	Growing (unsatisfied) demand for qualified staff limits the speed of deployment
5G/Wi-Fi 6 and 7	FTTA and points of access are required	Public-private coordination	More PPPs are needed to reduce deployment costs	5G/4G trade-offs	Fixed wireless access may be the best option for high-density urban spaces or remote areas (albeit with download limits)
Cost efficiency	Greater download can be provided more cost effectively by fiber than by wireless modes	Supply bottlenecks and increased costs	Importance of ensuring an uninterrupted supply to keep investments flowing and adjust to price increases	Predictability and return on investment	In markets with a low ARPU, depreciation of the local currency and economic uncertainty can discourage investment
Lower capital expenditure (CAPEX)	More willingness to share infrastructure; dig-once coordination policies	Extension of coverage to rural areas	Poor profitability due to distances, low population density, and geographical difficulties	Maximum use of legacy technologies	DOCSIS and HFC are still widely used and can provide acceptable services at a low price, which can delay the transition to fiber
National and financial plans	Initiatives to reduce gaps, implement subsidies, and gain multilateral support	Vandalism	Extremely frequent in the region due to disinformation; rapid service restoration plans are needed		
Leapfrogging	Jumping straight to high-capacity networks (XGS-PON) is an opportunity to reduce distances with the OECD				

Source: Authors' elaboration.

References

Bodine, S. 2021. The USDA is Helping Expand Rural Broadband, But Providers Face Equipment Shortages. KOSU. August 12. Available at https://www.kosu.org/technology/2021-08-12/the-usda-is-helping-expand-rural-broadband-but-providers-face-equipment-shortages.

Cabello, S., D. Ros Rooney, and M. Fernández. 2021. Nuevas dinámicas de la gestión de infraestructura de telecomunicaciones en América Latina. American Tower and SmC+. Available at https://americantower.com.mx/Assets/beta.americantower.com.mx/uploads/files/Nuevas_dinamicas.pdf.

FBA (Fiber Broadband Association). 2020. Operational Expenses for All-Fiber Networks are Far Lower Than for Other Access Networks. Available at https://fiberbroadband.org/wp-content/uploads/2023/03/Access-Network-OpEx-Analysis-White-Paper.pdf.

———. 2022. Strategies to mitigate bottlenecks.

FBA and Cartesian. 2019. Advanced Broadband Report.

FOSA (Fiber Optic Sensing Association). 2020. Dig once policy: 16 state models. July.

FTTH Council Europe. 2022. European FTTH/B Market Panorama 2021. Available at https://www.ftthcouncil.eu/knowledge-centre/all-publications-and-assets/191/european-ftth-b-market-panorama-2021.

FYCO and SmC+. 2022. White Paper. El valor de contar con una cadena de abastecimiento flexible para soportar el crecimiento de la fibra que experimenta América Latina. Available at https://www.fycotelecom.com/white-paper-fyco.

Glickman, C. 2022. How "dig once" can democratize digital connectivity. World Economic Forum. Available at https://www.weforum.org/agenda/2022/02/how-dig-once-policies-can-democratize-digitial-connectivity/.

Hardesty, L. 2021. Corning GM says fiber lead times are "much longer" than a month. *Fierce Telecom*. Available at https://www.fiercetelecom.com/broadband/co rning-gm-says-fiber-lead-times-are-much-longer-month.

infoDev (Information for Development) and ITU (International Telecommunications Union). 2009. Acceso y Servicio Universal (ASU). Módulo 4. Conjunto de herramientas para la reglamentación de las TIC.

Kim, J. 2022. Fiber Optic Cable Installation Process: Connecting Homes. Dgtl Infra. August 2. Available at https://dgtlinfra.com/fiber-optic-cable-installation-process/.

MinTIC (Ministerio de Tecnologías de la Información y las Comunicaciones). 2019. Proyecto Nacional de Fibra Óptica (Colombia). Available at https://mintic.gov.co/portal/inicio/Iniciativas/Sector-TIC/125120:Proyecto-Nacional-de-Fibra-Optica.

OECD (Organisation for Economic Co-operation and Development). 2023. Fibre is now the dominant broadband access technology in half of all OECD countries. Broadband Statistics Update. February 23. Paris: OECD. Available at https://www.oecd.org/digital/broadband/broadband-statistics-update.htm.

OECD and IDB (Inter-American Development Bank). 2016. Competition and Infrastructure Bottlenecks. In OECD and IDB, *Broadband Policies for Latin America and the Caribbean: A Digital Economy Toolkit*. Paris: OECD Publishing. Available at https://doi.org/10.1787/9789264251823-en.

Ros Rooney, D., M. Fernández, S. Beltrán, and S. Cabello. 2022. FTTH Panorama for Latin America 2022. FBA LATAM Chapter. Available at https://fiberbroadband.org/wp-content/uploads/2023/04/Latam-FTTH-Panorama-2021-Report.pdf.

Russell, E. 2020. Despliegue de infraestructura y conflictos municipales. Algunos enfoques posibles para cambiar el paradigma actual. Expert Insight Series No. 1. SmC+. July. Available at https://drive.google.com/file/d/1aHye8e7s8P_yzA8X8_-G_nrSeWYGAnvv/view.

Sevilla, G. 2021. Severe fiber shortage delays half a million AT&T internet installations. *Insider Intelligence*. August 13. Available at https://www.insiderintelligence.com/content/severe-fiber-shortage-delays-half-million-at-t-fiber-installations.

Annex. Regulations for Fiber Optic Deployment

Table A.1.

Fiber Optic Deployment: Most Significant Regulations in Selected Countries

Country	Regulation details
Argentina	• Resolution 105/2020.[a] The Passive Infrastructure Sharing Regulation (Reglamento de Compartición de Infraestructura Pasiva) establishes parameters to stimulate sharing, through signed agreements with freely defined conditions, following the principles of the regulation. • Resolution 292/2021.[b] Regulates the installation of infrastructure for ICT services in real estate.
Brazil	• Law 13116/2015.[c] The sharing of passive infrastructure is mandatory, except when there is a technical justification for not doing so. • Resolution 683/2017.[d] Regulates the shared use of infrastructure that supports telecommunications service provision. Encourages optimization of resources and the reduction of operational costs to benefit the end service users. Avoids duplication of infrastructure for service provision.
Chile	• Law 20808/2018 and Decree 167 of 2016.[e] The law of conduits regulates the format and conditions for guaranteeing freedom of choice in contracting and receiving telecommunications services in lots, buildings, and co-owned real estate. Similarly, it conceptualizes and establishes the general design of the internal telecommunications network (ITN). • Law 18168.[f] The concessionaries of public services are obliged to share passive infrastructure according to the Telecommunications Law.
Colombia	• Resolution 5050/2016.[g] Compiles general CRC resolutions and establishes conditions of access to the ITN. • Resolution 5890/2020.[h] Obliges telecommunications operators to share passive infrastructure in electricity networks. • Resolution 5283/2017.[i] Establishes a new passive infrastructure sharing regime, which includes rules regarding demarcation of conduits and posts and a new methodology for calculating prices.

(continued on next page)

Table A.1. *(continued)*

Fiber Optic Deployment: Most Significant Regulations in Selected Countries

Country	Regulation details
Costa Rica	• Law 10216.[j] Promotes, albeit voluntarily, the shared use of infrastructure between operators. Similarly, it establishes administrative silence, regulates the placement of underground conduits, and obliges all stakeholders to coordinate to avoid process duplication. • Resolution RJD-222–2017.[k] Regulates the shared use of infrastructure for public telecommunications networks and states that the sharing of passive infrastructure is mandatory.
Ecuador	• Resolution 144/2017.[l] The resolution technically regulates the deployment of underground infrastructure and underground physical networks for service provision. • Resolution 0807/2017.[m] Regulates the shared use of physical infrastructure; applies to all service providers under the general telecommunications regime. • Ministerial Agreement 017/2017.[n] Approves the national technical rules to set compensation levels for the use of posts and conduits for the installation of telecommunications networks.
Mexico	• Sharing passive infrastructure is mandatory for operators with a significant share of the market.[o]
Peru	• Decree 034/2010.[p] Establishes the obligation to install fiber optic in new electrical energy transmission and hydrocarbon transport projects, as well as conduits and ducting in highway infrastructure. • Legislative Decree 1019.[q] Establishes obligations for the sharing of passive infrastructure for significant providers of public telecommunications services.

Source: SmC+, based on information from regulators.
Notes:
[a] Resolution 105/2020 can be found at https://www.boletinoficial.gob.ar/detalleAviso/primera/238609/20201216.
[b] Resolution 292/2021 is available at https://www.boletinoficial.gob.ar/detalleAviso/primera/248093/20210813.
[c] Law 13116 of 2015 can be found at http://www.planalto.gov.br/ccivil_03/_ato2015-2018/2015/lei/l13116.htm.
[d] Resolution 683/2017 is available at https://informacoes.anatel.gov.br/legislacao/resolucoes/2017/949-resolucao-683.
[e] Law 20808 is available at https://www.bcn.cl/leychile/navegar?idNorma=1074272 and Decree 167/2016 at https://www.subtel.gob.cl/wp-content/uploads/2018/04/DO_decreto_167.pdf.
[f] Law 18168 is available at https://www.bcn.cl/leychile/navegar?idNorma=29591.
[g] Resolution 5050/2016 can be found at https://normograma.mintic.gov.co/mintic/docs/resolucion_crc_5050_2016.htm#Inicio.
[h] Resolution 5890/2020 is available at https://www.sic.gov.co/sites/default/files/documentos/022022/Resolucion-5890-de-2020.pdf.
[i] Resolution 5283/2017 can be found at https://www.crcom.gov.co/es/node/3108.
[j] Law 10216 is available at https://www.crhoy.com/wp-content/uploads/2022/07/ley-10216.pdf.
[k] Resolution RJD-222-2017 can be found at http://www.pgrweb.go.cr/scij/Busqueda/Normativa/Normas/nrm_texto_completo.aspx?param1=NRTC&nValor1=1&nValor2=85283&nValor3=110234&strTipM=TC#up.
[l] Resolution 144/2017 is available at https://www.arcotel.gob.ec/wp-content/uploads/2017/06/029_norma-tecnica-despliegue-networks-fisicas-servicios-telecommunications.pdf.
[m] Resolution 0807/2017 can be found at https://www.arcotel.gob.ec/wp-content/uploads/downloads/2017/08/Resolucion-0807-ARCOTEL-2017.pdf.
[n] Ministerial Agreement 017/2017 can be found at https://www.telecommunications.gob.ec/wp-content/uploads/2017/10/Acuerdo-017-2017.compressed.pdf.
[o] For more information, see "Las obligaciones de preponderancia también alcanzan a Fibra Sites de Slim, define IFT," El Economista, August 2020. Available at https://www.eleconomista.com.mx/firms/Las-obligationes-de-preponderancia-tambien-alcanzan-a-Fiber-Sites-de-Slim-define-IFT-20200824-0038.html.
[p] Decree 034/2010 is available at https://www.gob.pe/institucion/mtc/normas-legales/9976-034-2010-mtc.
[q] Legislative Decree 1019 can be found at https://www2.congreso.gob.pe/sicr/cendocbib/con4_uibd.nsf/8400371A3BF22EF605257BC8005A3B17/$FILE/DL_1019.pdf.

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