

FINANCING BROADBAND NETWORKS OF THE FUTURE

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Foreword

This report was prepared by the Working Party on Connectivity Services and Infrastructures (WPCSI). It analyses current trends in financing broadband networks and their implications for the future of connectivity. It focuses on five important groups that invest in and provide funding for broadband infrastructure: communication operators, tower companies, big technology companies, financial asset managers, and the public sector.

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Executive Summary

From connecting the unconnected to upgrading existing broadband networks for next generation access, continuous investments are needed to foster an inclusive access to high-quality connectivity. The report analyses current trends in financing broadband networks and their implications for the future of connectivity. It focuses on five important groups that invest in and provide funding for broadband infrastructure: communication operators, tower companies, big technology companies, financial asset managers, and the public sector.

On average, communication operators grew their revenues by two percent, and demonstrated stable profit margins while also increasing their debt levels

Communication operators contribute a significant portion of overall investments in fixed and mobile broadband networks. From 2008 to 2022, operators experienced an average growth rate of their revenues of 2.1% and demonstrated stable profit margins on average, with earnings before interest, taxes, depreciation, and amortisation (EBITDA) exceeding 30% and earnings before interest, taxes (EBIT) exceeding 14%. However, the return on invested capital (ROIC) of communication operators has gradually decreased. This decline as well as the convergence of ROICs between incumbents and challengers may result from differences in cost of capital and market conditions, management decisions as well as levels of competition. The analysis further reveals an upward trajectory in debt levels, as demonstrated by net debt to EBITDA ratios for communication carriers. The increased willingness to take on debt as observed until 2022 may be attributed to the availability of low-cost capital.

Global System for Mobile Communications (GSMA) Intelligence data on mobile operations consistently shows higher average revenue per user (ARPU) levels for mobile operators in the United States and Canada compared to Europe. Notably, Europe and the Asia Pacific region saw declines in ARPU between 2008 and 2022, while the United States and Canada experienced only a slight decrease. It is crucial to consider various factors such as the services offered and data allowances when interpreting these differences, as well as price levels for communication services.

Revenue, return, and interest rate developments determine future investment appetite

Investments in broadband deployment and development by operators, as illustrated by capex-to-sales ratios, are important and support the deployment of broadband infrastructure. The average capex-to-sales ratio for communication carriers rose slightly in 2021 and 2022.

Solid revenue is an important element of decisions to increase investment whereas decreasing return on invested capital (ROIC) compounds the challenge of garnering support for additional investments, especially with respect to maintaining shareholder value through dividend yield. However, requirements differ among financial investors, as some are accustomed to foregoing dividends for a period while expecting value upon exit, while others demand a continuous flow of dividends to retain their shares. Operators underperformed general market indices despite providing shareholders with substantial dividends financed by cash flow. While this report does not suggest a decline in investments in the observed period, the future will show if the industry faces obstacles in pursuing investments due to higher financing costs, potential changes in risk profiles of investments, and diminishing ROICs.

Mobile network operators seek to benefit from past investment in passive infrastructure to raise capital while tower companies are on the rise

Many mobile network operators (MNOs) have divested in towers to free capital for other investments, which in turn has led to a sharp rise of tower companies, some of which are starting to explore broader service offerings. Four different generations of tower arrangements may be distinguished. In the first generation, MNOs owned their towers outright. In the second generation, MNOs shared towers but still fully owned and operated them. The third generation involves a separation of tower ownership and operation, with many MNOs selling their towers and becoming anchor tenants. Some chose to sell full or majority stakes in their towers and become long-term tenants, some sold minority portions through taking on partners or stock market floats of spun-off units, and others by simply creating a separate unit to sell space to competitors. A fourth model is emerging, where tower companies expand their services, for example by operating on a familiar business model in property markets by leasing space, collecting, and increasingly buying or partnering with data centre companies.

Big technology companies and financial asset managers are reshaping the communication infrastructure landscape with global investments

A wide variety of stakeholders develop and invest in their own communication infrastructures, with differing roles in the overall connectivity ecosystem. This report uses cases from the five largest tech companies in terms of market capitalisation that invest in communication infrastructure. These companies increased their investment in backbone and access networks, particularly in submarine cables. In addition, tech companies build large data centres around the world and host data for their own service offerings and for third parties. Investments by technology companies primarily aim at efficient and stable traffic distribution. To achieve these goals, tech companies work together with communication operators in various areas within the communication infrastructure ecosystem.

Financial asset managers, including private equity firms, hedge funds and pension funds, play an increasingly significant role in funding communication infrastructure. These funds are investing heavily in wholesale fibre access networks, reshaping the connectivity landscape, particularly in rural and remote areas. This shift in investment patterns is exemplified by the substantial growth of raised capital by private equity funds focused on communication infrastructure. The expansionary policies of central banks, combined with low interest rates and a global surplus of savings, have incentivised asset managers to seek long-term investments in communication infrastructure. While ongoing projects are usually hedged, increasing interest rates could put parts of greenfield investment at risk.

The public sector plays an important role in both investing in and enabling investments in communication infrastructure

While recovery from the COVID-19 health crisis devoted to broadband network deployment may be categorised as a short-term goal, OECD countries also invest significant public funds in the deployment of broadband to bridge connectivity divides with a long-term perspective. Moreover, in recent years, the environmental sustainability of communication networks has become an increasingly important policy objective mirrored in funding initiatives. Public funding of broadband infrastructure should have a well-defined purpose, avoid distorting competition, utilise diverse funding methods, prioritise transparency in fund management, consider regional needs when selecting technologies, maintain technology neutrality and rely on objective criteria for cost-effective results. While public funds are one way to increase the deployment of broadband networks, the public sector has a crucial role in shaping regulatory frameworks that are conducive to investments in the communication sector and optimise the domestic environment to attract investments, while maintaining other goals such as competitive landscape and innovation in the market.

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Financing Broadband Networks of the Future

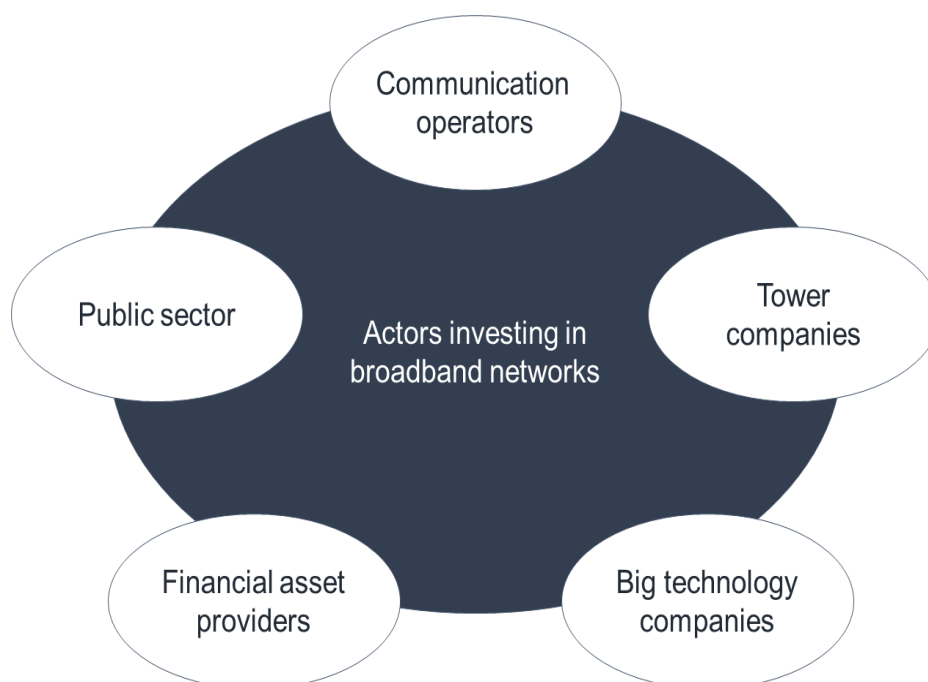
Introduction

Financing is essential to foster an inclusive access to high-quality connectivity, whether to connect those currently without access to connectivity or to upgrade existing broadband networks to enable next generation access. Ubiquitous and inclusive access to broadband connectivity is a necessity for further digital transformation, economic growth, and productivity. The challenge for OECD countries lies in ensuring adequate and long-term financing of broadband connectivity. The answer to this question determines how broadband networks will evolve and the coverage and quality they can provide.

The diversity, and hence complexity, of the financial landscape around connectivity infrastructure and services has increased constantly. While, for a large part of the 20th century, single entities in OECD countries had a monopoly in infrastructure and services, the liberalisation of markets has not only led to different players with a range of different business models, but also to different levels of infrastructure and service provision in different regions and countries. This, in turn, corresponds to multiple different ways to finance communication infrastructure and structure its ownership.

This report takes account of this increasing diversity and analyses current trends in financing broadband networks and their implications for the future of connectivity infrastructure and services. It first looks at the private sector and the main traditional players in providing broadband connectivity: how are communication operators investing in networks and how are they doing financially? One important change on the balance sheets of some operators are recent divestments of parts of their infrastructure to tower companies. These, in turn, keep growing in OECD countries and invest in passive, but more recently also in active, communication infrastructure. The report takes a closer look at these transactions and the investments and financial situations of tower companies. Big technology companies (“tech companies”) represent an important group of the wide variety of stakeholders that actively contribute to investments in broadband infrastructure. While the business of big technology companies includes important investments in other parts of the digital ecosystem, this report sheds light on their communication infrastructure investments. Outside the purely digital ecosystem, financial asset managers such as private equity companies or pension funds show an increasing appetite in financing broadband networks across several OECD countries. One common denominator of these investments is that they target the deployment of wholesale access networks, thus changing the overall structure of the connectivity ecosystem. This is especially the case in rural and remote areas as well as for fibre backbones in certain countries. The public sector continues to play an important role in funding broadband networks, and not only through recent economic recovery packages. Several OECD countries currently engage in funding connectivity infrastructure. This is particularly the case in areas where private actors are not closing connectivity gaps and in situations where the quality of connectivity is deemed insufficient. The report takes stock of public funds, including recovery packages, and examines how money provided by them has been spent. This section also includes information on utilities and community networks. Other areas such as investments in the self-provision of networks such as local 5G networks, or indoor networks, as well as investments in emerging connectivity services are not considered in this report due to the lack of data.

Figure 1. Examined actors investing in broadband networks



Note: This typology is tailored to the actors studied in the context of this paper.

Communication operators today

Communication operators are at the forefront of driving digital transformation and societal advancement through the provision of high-quality broadband infrastructure for communication services and play an important part in investing in fixed and mobile broadband networks. Conducting a comprehensive examination of their financial performance is thus key, with a specific focus on their potential to invest and foster the further development and provision of high-quality broadband services. To gain a broad understanding of the ecosystem, this chapter adopts a broad perspective by analysing the financial performance of communication operators as an aggregate, rather than focusing solely on individual companies. This section presents financial data on communication operators, encompassing the period between 2008 and 2022/2023. The analysis builds upon and extends the groundwork laid in the previous OECD report on “*Communication Operators and their Future*” that also observed a 15-years period (OECD, 2019^[1]).

The analysis encompasses 195 publicly listed companies that offer communication services or are facilitators for communication services as categorised by Bloomberg (Annex A). To capture the ecosystem of communication operators effectively and to acknowledge the broad range of entities involved in providing communication services, the report classifies companies into the following categories, based on the Bloomberg categorisation: Telecommunication Carriers (139 companies), Cable & Satellite (37 companies), Infrastructure Construction (11 companies), Consumer Electronics (3 companies), and Publishing & Broadcasting (5 companies). The Bloomberg data set covers five regions according to its categorisation: Asia Oceania, Europe, Latin America, Middle East Africa, and the United States and Canada.

Linking the analysis to the liberalisation of the communication sector, the companies are either labelled as incumbents (52 companies) or challengers (143 companies). The role of specific communication operators may change given the international nature of communication operators and varying national

characteristics. The labelling is primary derived from the historical role of the communication operator in the respective home market. Most companies in the Infrastructure Construction bucket are tower companies (9 out of 11), which are dealt with in detail in the section “Tower companies on the rise”.

Financial data provided by Bloomberg has been converted to US dollars to enable a meaningful comparison.¹ The analysis was conducted based on a revenue-weighted average, ensuring a comprehensive evaluation of the financial performance of communication operators. The Bloomberg data covers the period from 2008 to 2022. The dataset is described in more detail in the Annex 1.A.

This report also incorporates an analysis of GSMA Intelligence data specifically focusing on operators providing mobile services. This additional dataset comprises 132 companies from all 38 OECD countries and spans the period from 2008 to 2023. This data allows for a well-rounded understanding of the financial trajectory of communication operators within the dynamic mobile services sector. The examined data contains nominal values converted to USD via spot rates from GSMA Intelligence data.

This chapter begins by examining revenues, including the Average Revenue per User (ARPU) of the companies in the data set. Revenues are used to calculate the revenue weighted average for various parameters. The report then considers profitability by analysing the earnings before interest, taxes, depreciation and amortisation (EBITDA) margin. The operating margin, earnings before interest and taxes (EBIT), is then presented, considering depreciation and amortisation expenses. As the deployment of infrastructure is a vital part of communication operators’ ongoing business, capital expenditures (investments) are analysed and set in relation to revenues. As the high capital intensity of communication infrastructure investments needs to be financed either through cash flow generated by operations or by debt, net debt (debt subtracted by the company’s cash), is set in relation to EBITDA. The financial outcome is evaluated through the return on invested capital (ROIC) and its evolution over time. ROIC indicates how effectively a company utilises its capital to generate returns. In a final step, this section looks at share price developments of communication operators and the overall stock market.

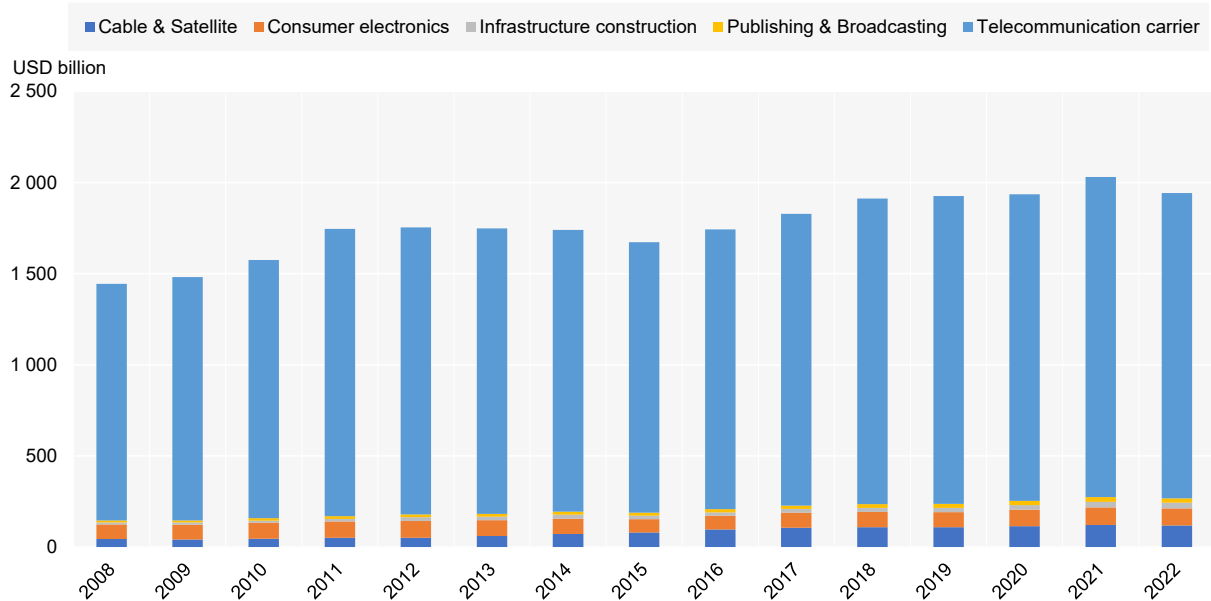
Revenues

Revenues are an essential indicator of a company's financial performance and can demonstrate its ability to generate income. Revenues reflect business growth, market position and provide the basis for financial stability. Sufficient revenues are necessary to cover operating expenses, investments, debt repayments, to generate profits and pay dividends.

In general, revenues from communication operators represent a significant part of the economy. In 2022, the 195 companies in the Bloomberg dataset generated revenues of USD 1.9 trillion, consisting mostly of revenues from fixed and mobile broadband services. The compounded average growth rate (CAGR) for revenues in the examined timeframe from 2008-2022 amounted to 2.1%. Revenues declined by 4.4% in 2022 after a growth of 4.9% in 2021 and 0.5% in 2020 (Figure 2)².

Figure 2. Revenues grew by a compounded average rate of 2.1% between 2008 and 2022

Total revenues of telecommunication carriers, cable & satellite companies, infrastructure construction companies, consumer electronics companies, and publishing & broadcasting companies, 2008 – 2022



Source: Adapted from Bloomberg (2023), Bloomberg Terminal, <https://www.bloomberg.com/professional/products/bloomberg-terminal> (accessed 15 September 2023)

Zooming into the mobile sector and into regions, global mobile revenues in current USD amounted to USD 612.9 billion in 2023, according to GSMA Intelligence data.³ Of this, the United States and Canada generated 50% (USD 305 billion), Europe 28% (USD 169 billion), Asia Pacific 18% (USD 110 billion) and Latin America 5% (USD 29 billion). The regional stakes in overall mobile revenues vary over time. In 2008, for example, the United States and Canada generated 38% (USD 182 billion) of the overall revenues (USD 481 billion), largely in par with Europe (USD 187 billion). Asia Pacific generated 20% (USD 96 billion) and Latin America 3% (USD 16 billion).

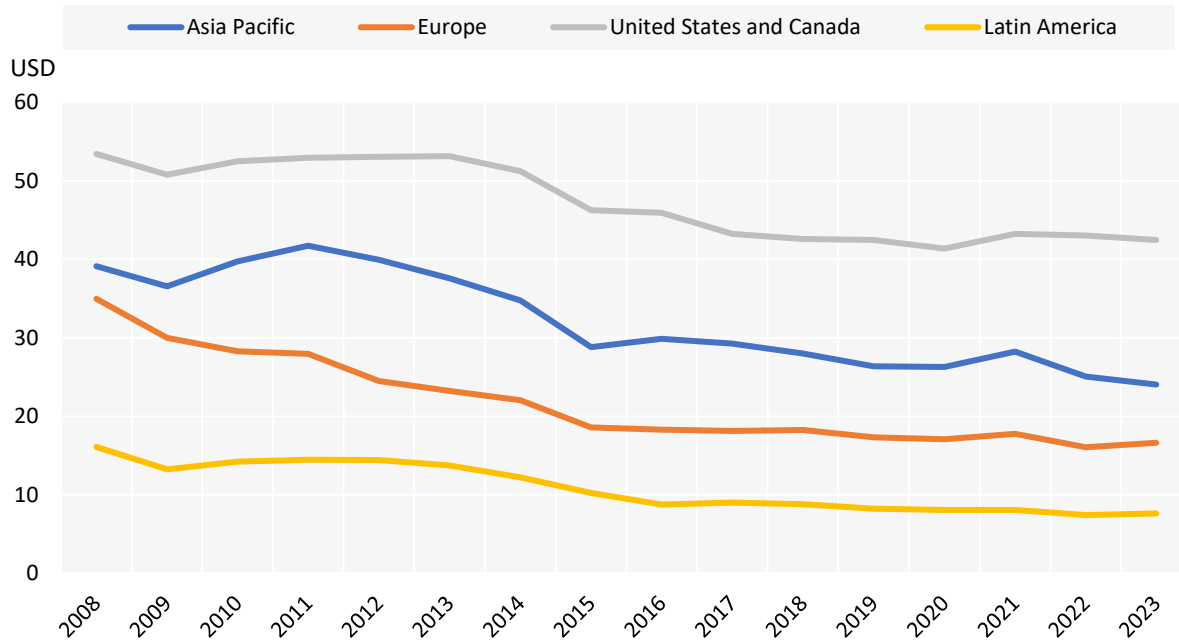
The evolution of mobile average revenue per user (ARPU) offers further valuable insights into the average revenue generated by mobile communication operators from individual subscribers monthly. To present inflation-adjusted ARPU levels in USD, a deflator is used based on the consumer price index (CPI) applied to individual OECD countries, before aggregating by region. From 2008 to 2023, ARPU figures varied across different regions. In the United States and Canada ARPU averaged USD 47 for this period, whereas in the Asia Pacific region it stood at USD 32. In Europe the average ARPU was USD 22, while it amounted to USD 11 in Latin America. Notably, in 2023, the highest ARPU was observed in the United States and Canada at USD 42, followed by USD 24 in the Asia Pacific region, USD 17 in Europe and USD 8 in Latin America.

Examining the compounded annual growth rate (CAGR) for inflation-adjusted ARPUs over the 2008-2023 period reveals that European and Latin American mobile operators experienced the largest decline, with a CAGR of -4.83%, and -4.88% respectively. The United States and Canada witnessed a more modest decline of -1.52%, while Asia Pacific recorded a decrease of -3.19%. The cumulative effects of the declines over 15 years vary in impact. Cases in point are Europe and Latin America, where ARPU decreased from USD 34.96 and USD 16.11 in 2008 to USD 16.6 and USD 7.6 in 2023, reflecting a decline of -52% and -53% respectively (see Figure 3). At the same time, however, the number of mobile broadband

subscriptions has grown significantly from 2010 to 2022, with a growth of 118% in Asia Pacific, 241% in Europe, 212% in the United States and Canada, and 1178% in Latin America (OECD, 2024^[2]).

Figure 3. Inflation-adjusted mobile average revenue per user (ARPU) declined between 2008 and 2023

Development of mobile average revenue per user (ARPU) in OECD countries in the Asia Pacific, Europe, United States and Canada, Latin America, inflation adjusted



Note: : Nominal ARPU figures have been deflated per country per year, using the OECD annual Consumer Price Index (CPI) (based on 2015) and then converted to USD with current exchange rates.

Source: Adapted from GSMA Intelligence (2024), GSMA Intelligence, <https://www.gsmainelligence.com/> (accessed on 15 January 2024)

The higher inflation-adjusted ARPU figures observed in the United States and Canada may be explained by several factors. Within the OECD area, prices for communication services for consumers and businesses are comparatively high in the United States and Canada which may reflect lower levels of competition in the market, most acute in rural and remote areas (OECD, 2023^[3]), among other factors. In addition, revenues can also be linked to investment strategies, such as relatively high levels of deployment. Furthermore, the presence of diverse family plans and a greater prevalence of post-paid subscriptions, which often tend to be more expensive than entry-level prepaid ones may contribute to the elevated ARPU in this region. Conversely, the declining ARPU in Europe may be a result of increased levels of competition, with operators and other players striving to offer enhanced consumer value, particularly in terms of data. In Latin America, the lower ARPU may be attributed to a larger share of prepaid subscriptions and lower overall purchasing power. The GDP per capita in 2022 was USD PPP 54 000 in the European Union and USD PPP 19 000 in Latin America (Worldbank, 2023^[4]). Market conditions and regulatory environments within the communication industry vary across regions. In particular, Europe has seen a development towards more competitive prices over the past years because of market dynamics in Europe as well as ex-ante regulation and ex-post enforcement.

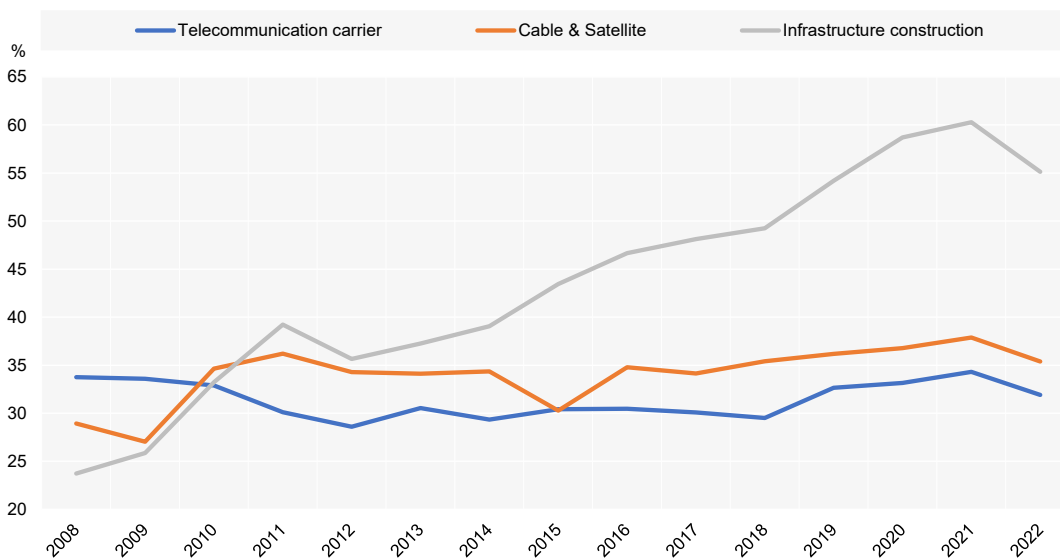
Earnings before interest, tax, depreciation and amortisation (EBITDA)

Earnings before interest, taxes, depreciation and amortisation (EBITDA) is an indicator of a company's financial performance in operations. However, it does not consider the cost of debt and depreciation, which are substantial for capital-intensive operators. EBITDA as a proportion of revenues or sales is referred to as the EBITDA margin. This measure can give a sense of how a business' operations are performing.

The average EBITDA margin for communication carriers between 2008 and 2022 was 31.4% and increased to 33.2%, 34.3% and 31.9% in 2020, 2021 and 2022, respectively. Cable & Satellite companies had an average EBITDA margin of 34.0% between 2008 and 2022. The category of infrastructure construction companies, mainly composed of tower companies in the Bloomberg sample (9 out of 11), outperform the other communication operators and even improved their EBITDA margins over time, reaching margins of 60.3% and 55.1% in 2021 and 2022, respectively. This compares to an average of 43.3% for the entire timespan under study. The outstanding EBITDA performance of infrastructure construction companies may explain the interest of alternative asset managers which are increasingly entering this field (See "Financial asset managers shaping the connectivity ecosystem"). The operating costs of these companies are lower compared to vertically integrated communication carriers, as infrastructure companies tend to have no retail business. Tower companies commonly have been able to strike long-term contracts providing the companies with recurring revenues and an ability to control their costs, which in turn enables better access to debt financing. Increased colocation on tower company sites could also factor to increase their profit margins over time. Finally, tower companies often face limited competition because of long-term contracts and a high level of capital intensity which puts significant barriers to market entry.

Figure 4. EBITDA margins of telecommunication carriers and cable & satellite companies were stable, while EBITDA margins of infrastructure construction companies increased almost consistently

Earnings before interest, taxes, depreciations and amortisation (EBITDA) margins for telecommunication carriers, cable & satellite companies and infrastructure construction companies, 2008 – 2022



Source: Adapted from Bloomberg (2023), Bloomberg Terminal, <https://www.bloomberg.com/professional/products/bloomberg-terminal> (accessed 15 September 2023)

The EBITDA margins of challengers and incumbents were at 30.4% and 32.7% in 2022, respectively. Challengers strengthened their EBITDA margins over time, starting at a margin of 23.4% in 2008 and attaining an average margin of 26.7% between 2008 and 2022. The EBITDA margins for incumbents saw a decline, from 36% in 2008 to an average margin of 33.3% between 2008 and 2022.

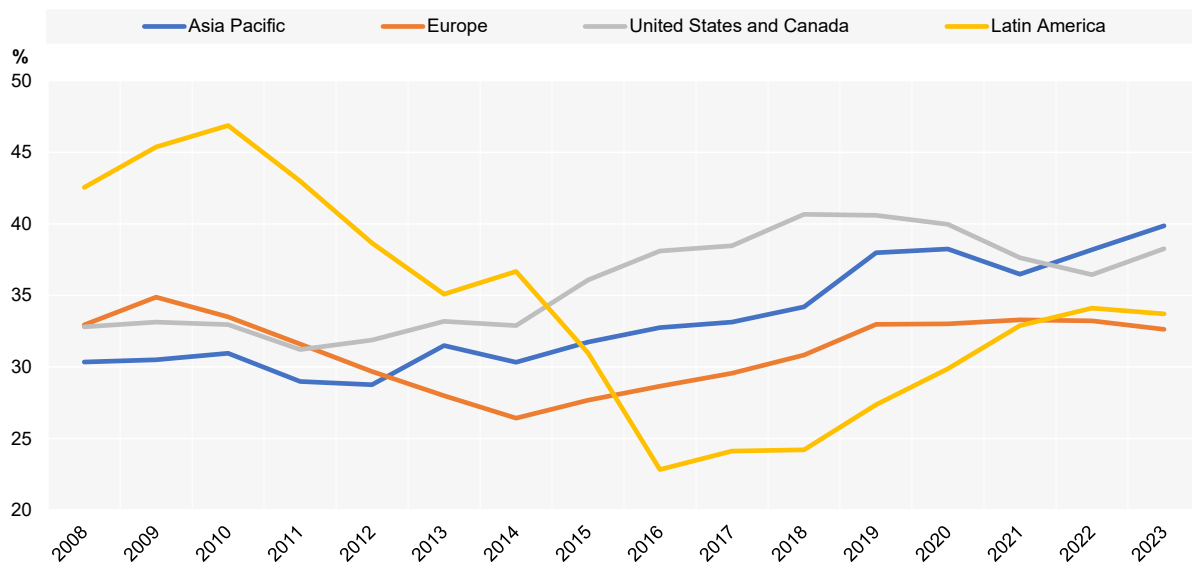
In the GSMA Intelligence data of mobile operations, companies generated EBITDA margins of 38.3% in the United States and Canada, 33.7% in Latin America, 39.9% in the Asia Pacific and 32.6% in Europe between 2008 and 2023. Comparing both EBITDA indicators in the Bloomberg and GSMA datasets, this indicates that mobile operations may be slightly more profitable than communication services in general.

For mobile operations, the volatility of EBITDA margins differs across regions. The EBITDA margin in Latin America is characterised by large fluctuations, which may partially be explained by the small sample size for Latin America in this analysis. EBITDA margins in Europe improved from 2014 (26.4%) and averaged 32.7% during 2018-2023, close to the first year observed in the dataset. In 2008, European mobile operators reached an EBITDA margin of 32.9%. The United States and Canada achieved an EBITDA margin of 39% between 2018 and 2023, followed by the Asia Pacific with 37.5% (See Figure 5).

As for overall revenues, regional differences in EBITDA margins may result from different market characteristics. For example, lower levels of competition may result in higher prices, in turn resulting in higher margins. In addition, factors like firm efficiency, cost structures and other operational costs directly influence EBITDA margins and may play a role in explaining regional differences.

Figure 5. Between 2008 and 2023 estimate, mobile operators generated EBITDA margins of 35.9% in the United States and Canada, 34.3% in Latin America, 33.4% in the Asia Pacific, 31.2% in Europe

Earnings before interest, taxes, depreciation and amortisation (EBITDA) margins for mobile communication operators in OECD countries in the Asia Pacific, Europe, United States and Canada, and Latin America, 2008 – 2023



Note: Data 2023 includes estimates for the third and fourth quarter.

Source: Adapted from GSMA Intelligence (2024), GSMA Intelligence, <https://www.gsmaintelligence.com/> (accessed on 15 January 2024) Earnings before Interest and Taxes (EBIT)

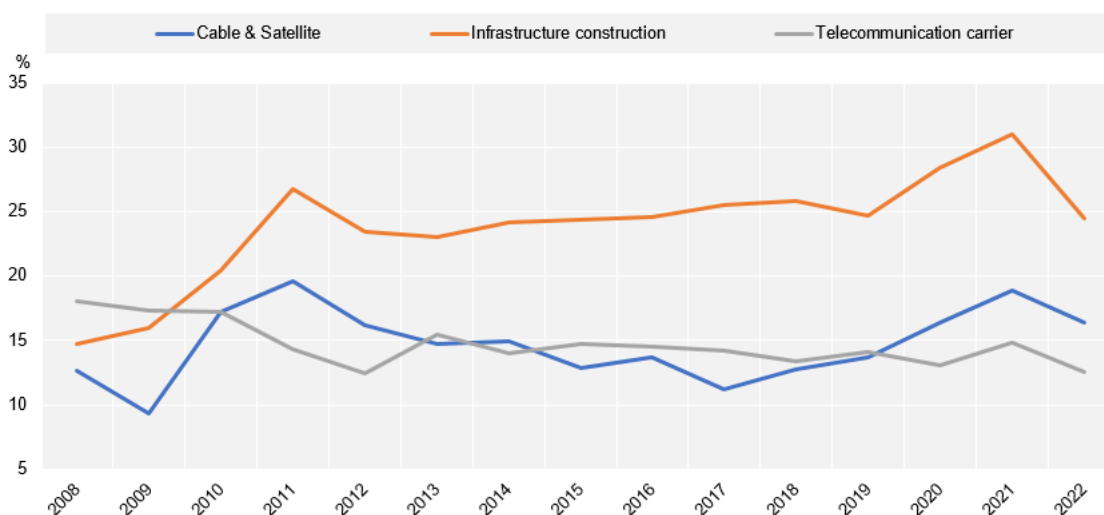
Given the capital intense nature of broadband networks, communication operators need to generate sufficient EBITDA margins to cover depreciation and amortisation. These expenses are deducted in the

EBIT margins. EBIT margins reflect the impact investments in infrastructure assets have on overall firm performance and they account for ongoing capital expenditure required for asset maintenance and replacement. As such, they provide a more focused view on overall financial performances.

EBIT margins for communication carriers have slightly decreased since 2008, while cable & satellite companies improved their EBIT margins. Both generated an average EBIT margin of 14.7% between 2008 and 2022. Infrastructure construction companies generated EBIT margins of 23.8% on average during the period of 2008 and 2022 (See Figure 6). Differentiating by incumbents and challengers, challengers generated an average EBIT margin of 11.9% and incumbents an average of 16%. EBIT margins for both groups have been relatively stable since 2012.

Figure 6. Between 2008 and 2022, telecommunication carriers and cable & satellite companies both averaged EBIT margins of 14.7%, while infrastructure companies achieved an average EBIT margin of 23.8%

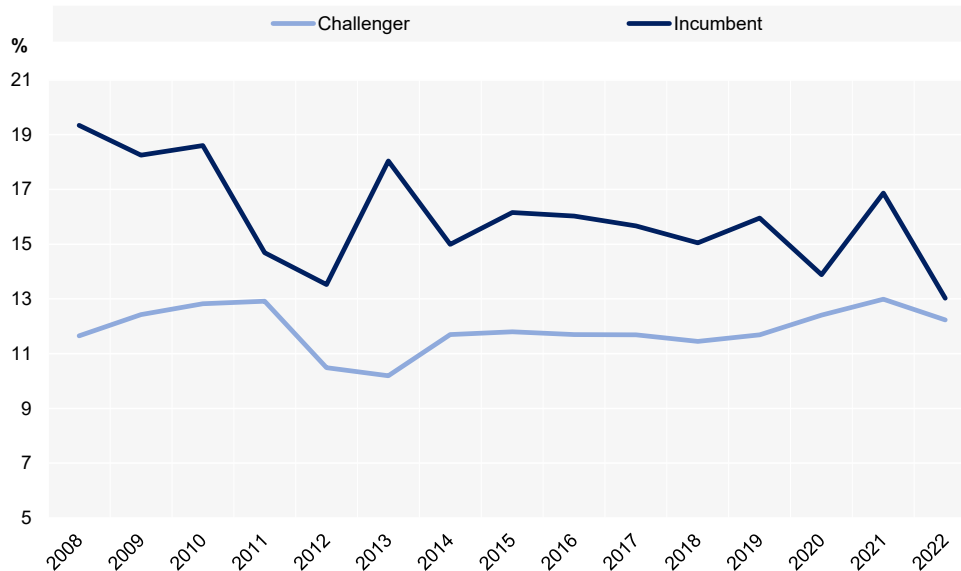
Earnings before interest, taxes (EBIT) margins for telecommunication carriers, cable & satellite companies and Infrastructure construction companies, 2008 – 2022



Source: Adapted from Bloomberg (2023), Bloomberg Terminal, <https://www.bloomberg.com/professional/products/bloomberg-terminal> (accessed 15 September 2023)

Figure 7. EBIT margins for both incumbents and challengers slightly converged between 2008 and 2022

Earnings before interest, taxes (EBIT) margins for incumbents and challengers, 2008 – 2022



Source: Adapted from Bloomberg (2023), Bloomberg Terminal, <https://www.bloomberg.com/professional/products/bloomberg-terminal> (accessed 15 September 2023)

Overall, the sector managed to increase total revenues by a CAGR of 2.1% over the 2008-2022 period, (in nominal values) according to the Bloomberg data set covering 195 companies (Figure 2).⁴ EBITDA margins were comfortable at average rates ranging from 31.4% for communication carriers and reaching an average rate of 43.3% for the infrastructure construction companies in this sample, which are mainly tower companies. EBIT rates are shown in Figure 6, reflecting firm performance after depreciation and amortisation of assets. They saw an average double-digit margin of about 15% for communication carriers and cable & satellite companies and reached an average EBIT margin of 23.8% for infrastructure construction companies. Furthermore, EBIT margins of challengers and incumbents slightly converged over the 2008 to 2022 period (Figure 7).

Investments

Infrastructure is a prerequisite for communication operators as it forms the backbone for their operations. Ensuring the provision of reliable and high-quality broadband services is paramount for operators to maintain and strengthen their competitive position in the market. By investing in both fixed and mobile broadband infrastructure, operators fortify their ability to stay competitive, meet the evolving demands of consumers and businesses and contribute to bridge connectivity gaps (OECD, 2021^[5]). Compared to other sectors, this means that the sector is capital-intensive and requires continuous capital expenditure (“capex”). Measuring capital expenditure in relation to sales (“capex-to-sales”) provides a comparable indication of the level of investments in the sector.

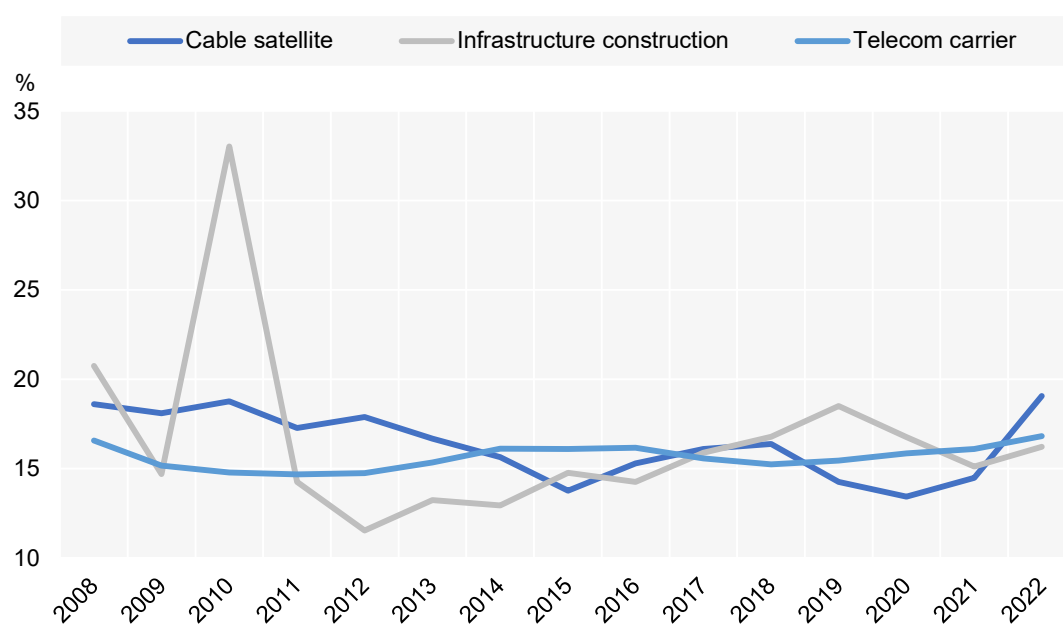
Total capex in the Bloomberg dataset, which includes investments in both fixed and mobile broadband networks, was USD 231.5 billion in 2008 and USD 317.6 billion in 2022, representing a growth of 37%. In 2022, capex of cable & satellite companies was USD 22.6 billion, USD 4.9 billion for consumer electronics, USD 5 billion for infrastructure construction companies, USD 3.6 billion for publishing & broadcasting companies, and USD 281.5 billion for telecommunication carriers. The average ratio of capex-to-sales for

communication carriers during 2008-2022 was 15.6% and relatively stable over this period. However, the ratio reached 16.1% in 2021 and 16.8% in 2022. The increased level of investment may be partially attributed to the impact of comparatively low interest rates. While overall capex numbers increased, changes over time in the capex-to-sales ratio may not only be affected by capex, but also changes in revenues. Overall, challengers seem to usually invest slightly less in relation to sales than incumbents. Their capex-to-sales ratio averages 14.4% between 2008 and 2022, while incumbents have an average ratio of 15.6%.

The capex-to-sales ratio for cable & satellite fluctuates over time and averages 16.4% during 2008-2022, with a peak of 19% in 2022. Infrastructure construction companies have an average capex-to-sales ratio of 16.6%. This may appear comparatively low given their focus on providing infrastructure. However, the number of companies represented in the infrastructure construction bucket is limited. This also explains the peak in 2010, in which one company (*Gtl Infrastructure*) increased its investment significantly (See Figure 8).

Figure 8. The capex-to-sales ratio of communication carriers was relatively stable between 2008 and 2022

Investments in network infrastructure measured as capital expenditures in relation to sales for cable & satellite companies, infrastructure construction companies and communication carriers, 2008 – 2022

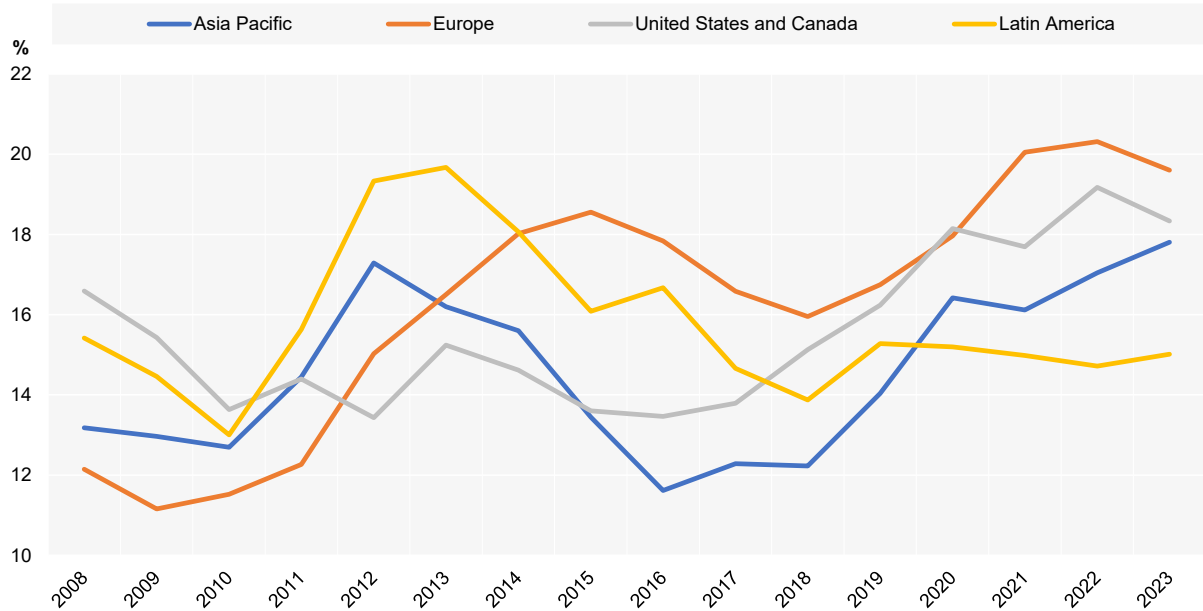


Source: Adapted from Bloomberg (2023), Bloomberg Terminal, <https://www.bloomberg.com/professional/products/bloomberg-terminal> (accessed 15 September 2023)

Total capex in the GSMA Intelligence data was 67.4 USD billion in 2008 and 106 USD billion in 2023, representing a 57% growth. The capex-to-sales ratios in the GSMA Intelligence data are less steady, which may reflect associated expenditure on successive generations of mobile technologies (i.e. 3G to 4G to 5G). The increased ratios in Asia Pacific, Europe, and the United States and Canada may indicate recent investments in 5G roll-out. On average, the capex-to-sales ratio was 14.6% in Asia Pacific, 16.3% in Europe, 15.6% in the United States and Canada, and 15.8% in Latin America. In 2023, Europe has the highest capex-to-sales ratio with 19.6% followed by the United States and Canada with 18.3%, Asia Pacific on 17.8%, and Latin America on 15%.

Figure 9. Capex-to-sales ratios of mobile operators fluctuated over time

Capex-to-sales mobile operators in OECD countries in Asia Pacific, Europe, United States and Canada and Latin America

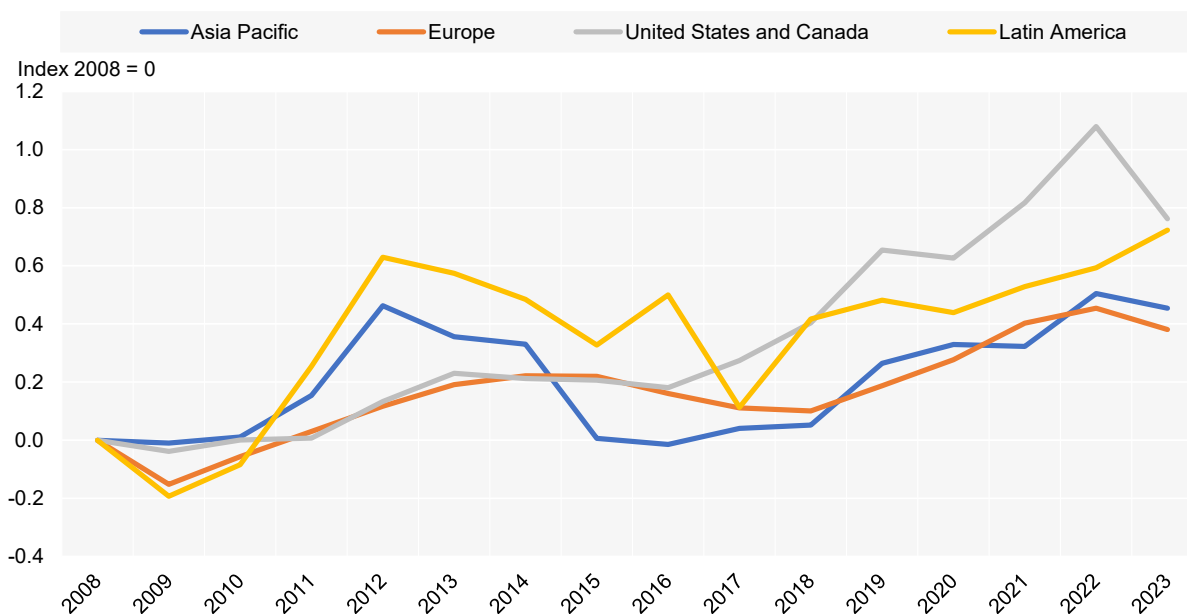


Source: Adapted from GSMA Intelligence (2024), GSMA Intelligence, <https://www.gsmainelligence.com/> (accessed on 15 January 2024)

Capex-to-sales ratios must be examined with attention to variation in the level of sales. In absolute values, investments increased almost steadily between 2008 and 2023. Indexing the values as a percentage change, it has to be recognised that Capex trends are cyclical, which could affect the value for the base year. Using 2008 as the base year⁵, the level of capital expenditure of mobile operators in 2023 was 76% higher in the United States and Canada, 38% higher in Europe, 72% higher in Latin America, and 45% higher in Asia Pacific. It has to be noted that while the capex-to-sales ratio in Europe was higher in 2023 (19.6% vs. 18.3%), Capex growth as depicted in indexed absolute values were higher in the United States and Canada compared to Europe (76% vs. 38%).

Figure 10. Indexed values of capital expenditure of mobile operators increased over time

Development of Capital expenditure in indexed absolute values over time for OECD countries in Asia Pacific, Europe, United States and Canada and Latin America



Source: Adapted from GSMA Intelligence (2024), GSMA Intelligence, <https://www.gsmaintelligence.com/> (accessed on 15 January 2024)

Financing and leverage

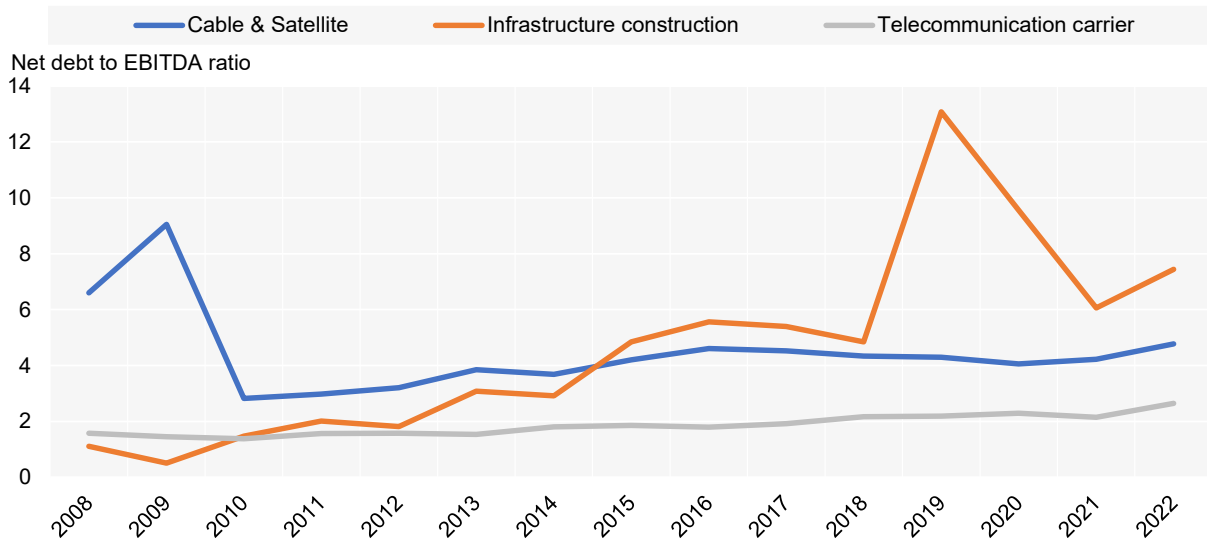
Investments, measured in constant 2015 USD, increased by 95% between 2008 and 2023 (USD 60 billion to USD 117 billion), according to the GSMA Intelligence data. Given this growth, it is worth looking at how these investments were financed. To get an overview of the different financial positions and risk profiles in the sector, this section examines the leverage ratio (measured as net debt to EBITDA). The ratio is calculated as a company's interest-bearing liabilities minus cash or cash equivalents divided by its EBITDA. It shows how many years it would take for a company to pay back its debt if net debt and EBITDA are held constant and thus represents a crucial indicator of a company's financial health and risk profile.

In general, the leverage ratio increased over time across the sector. Communication carriers had a net debt to EBITDA ratio of 1.6 in 2008 and 2.6 in 2022. Infrastructure construction companies actively used debt to expand and acquire assets with increasing ratios. While their net debt to EBITDA ratio was 1.1 in 2008, it grew to 7.4 in 2022. Debt ratios of cable & satellite companies initially fell from 6.6 in 2008 to 2.8 in 2010, but then climbed to 4.8 in 2022 (See Figure 11).

Given that revenues were not decreasing, gradual increases in leverage ratios may have been driven by a period of comparatively low interest rates and large amounts of available liquidity. In addition, they may have been a result of changing strategic priorities, which in turn may have partially led to debt-loaded corporate strategies. As a result, however, companies became more sensitive to the effects of potential decreases in EBITDA and/or increases in interest rates, e.g. EBITDA decreases if the operating cost increases meanwhile it has to cover larger costs of interests (both from higher interest rates and a larger stock of debt).

Figure 11. Debt ratios increased across the sector between 2008 and 2022

Net debt to EBITDA for telecommunication carriers, cable & satellite companies, and infrastructure construction companies, 2008 – 2022



Note: The strong increase in 2019 in the infrastructure construction category is largely due to the small number of observations in this category and driven by one company.

Source: Adapted from Bloomberg (2023), Bloomberg Terminal, <https://www.bloomberg.com/professional/products/bloomberg-terminal> (accessed 15 September 2023)

Return on Invested Capital

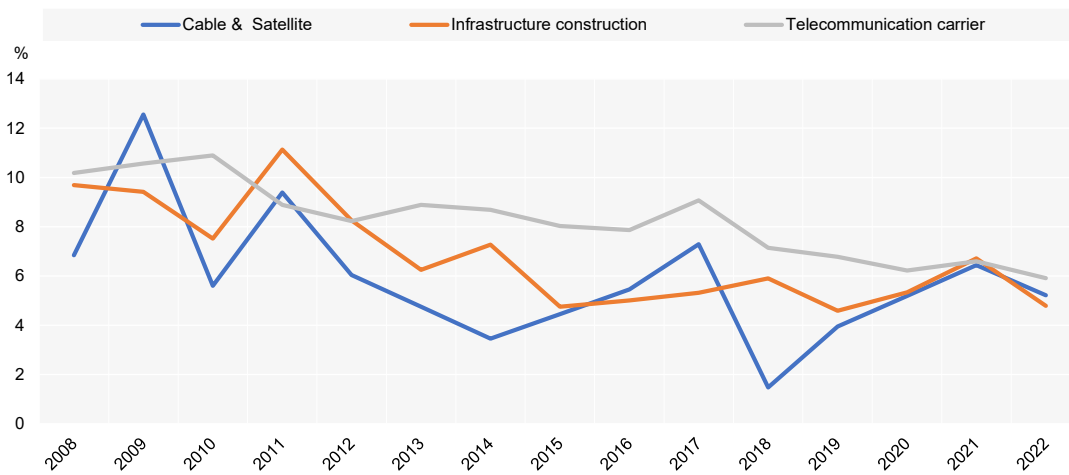
The substantial capital intensity characterising communication operations serves as a driving force for companies and investors to exercise diligent oversight over investment returns. Within this context, various methodologies exist for gauging such returns, among which this report focuses on the metric known as "return on invested capital" (ROIC), where "return" is measured as Net Operating Profit after Tax (NOPAT). This crucial indicator offers insights into the efficiency with which a company deploys its capital resources, encompassing both equity and debt, towards its operational endeavours. The return on capital stems from the interplay of operating profits, which encapsulate fixed expenses in conjunction with the impact of prior investments manifested through depreciation outlays.

ROIC in general declined between 2008 and 2022. Despite some fluctuations, between 2008 and 2022 ROIC fell from 10.2% to 5.9% for communication carriers, from 6.8% to 5.2% for cable & satellite companies, and from 9.7% to 4.8% for infrastructure construction companies. It is notable that ROIC for incumbents decreased from 10.9% in 2008 to 5.9% in 2022 while ROIC for challengers fluctuated around 6–8% during the same period. ROIC converged around 6% for both incumbents and challengers in 2022. As a comparison, the utility sector – in this case the 193 publicly listed companies belonging to the utility sector according to the Bloomberg classification – has a ROIC of 3.7% for the whole period and is comparatively higher during the second half of this period. As a further comparison, the technology sector (technology hardware, semiconductor, software and tech services), as classified by Bloomberg, generated an average ROIC of 6% in North America (161 firms) during 2008–2022 with significant fluctuations going from a ROIC of 13% in 2008 to -2% in 2016 up to 7% in 2022. The ROIC for 54 European technology firms, as classified by Bloomberg, was on average 14% during 2008–2022, maintaining stable returns over the period with 13% in 2008, slightly up to 15% in 2016 and 14% in 2022.

These observations align with the expected outcome of competitive markets. Potential concerns arise when ROICs fall to insufficient levels, which could have a negative effect on investment incentives. However, it is essential to recognise that the cost of capital varies among companies, markets and countries, thereby influencing the threshold at which low returns may become problematic with respect to further investment in different regions and with varying context. Maintaining an adequate level of ROIC is crucial for ensuring a sustained flow of investments in infrastructure.

Figure 12. Returns of Invested Capital (ROICs) have decreased over time

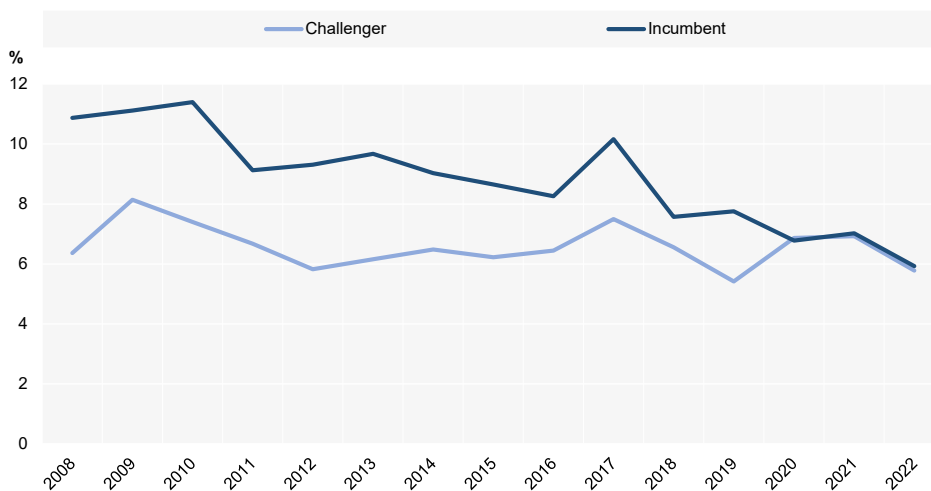
Return on invested capital (ROIC) for telecommunication carriers, cable & satellite companies, and Infrastructure construction companies, 2008 – 2022



Source: Adapted from Bloomberg (2023), Bloomberg Terminal, <https://www.bloomberg.com/professional/products/bloomberg-terminal> (accessed 15 September 2023)

Figure 13. Returns of Invested Capital (ROICs) of incumbents and challengers have converged over time

Returns of Invested Capital (ROICs) of incumbents and challengers, 2008 – 2022



Source: Adapted from Bloomberg (2023), Bloomberg Terminal, <https://www.bloomberg.com/professional/products/bloomberg-terminal> (accessed 15 September 2023)

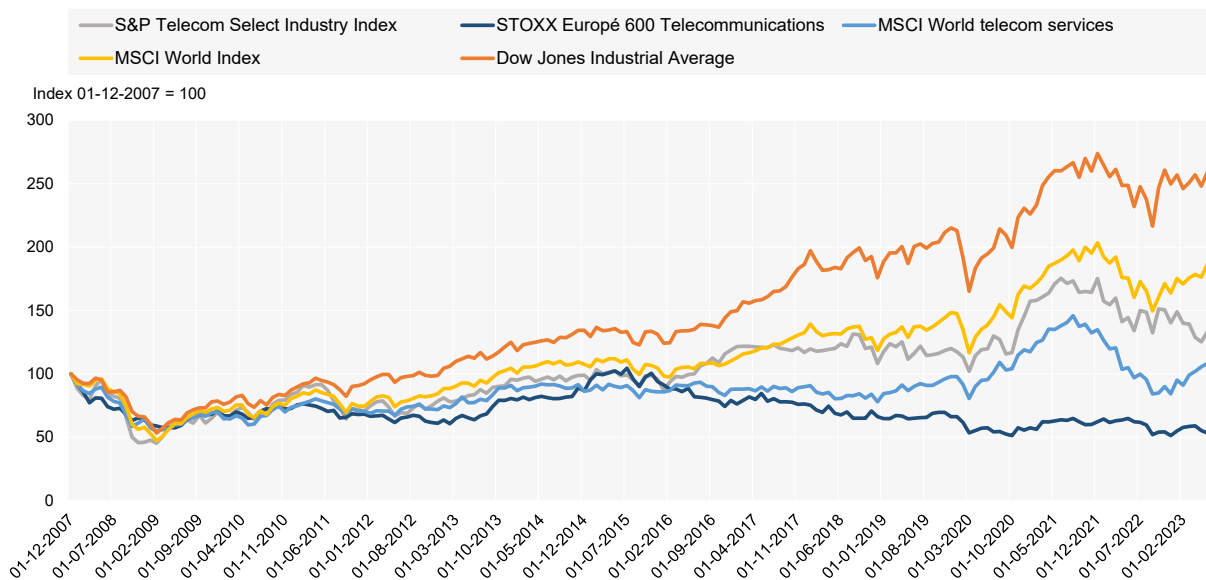
Stock Market

The stock market is continuously assessing the value of companies with a view to also anticipate their future performance. It is therefore relevant to examine how communication operators performed on the stock market relative to the overall market. The development of five indices, three of which represent communication operators in different geographies, is used to assess the performance of communication operators (Stoxx Europe 600 Telecommunications (focus on Europe); S&P Telecom Select Industry Index (focus on United States); MSCI World telecom services (Global)). Two indices are analysed for the overall stock market (Dow Jones Industrial Average (United States); MSCI World Index (Global)).

To compare the developments of these indices during the period 2008 to 30 June 2023, an index was constructed with 100 as base (as of 30 December 2007). Figure 14 shows the development of the indices between 30 December 2007 and 30 June 2023.

Figure 14. Stocks of communication operators have not been growing as much as benchmark indices

Indexed developments Stoxx Europe 600 Telecommunications, S&P Telecom Select Industry Index, MSCI World telecom services, Dow Jones Industrial Average, and MSCI World Index, 30 December 2007 – 30 June 2023



Source: Adapted from Bloomberg (2023), Bloomberg Terminal, <https://www.bloomberg.com/professional/products/bloomberg-terminal> (accessed 15 September 2023)

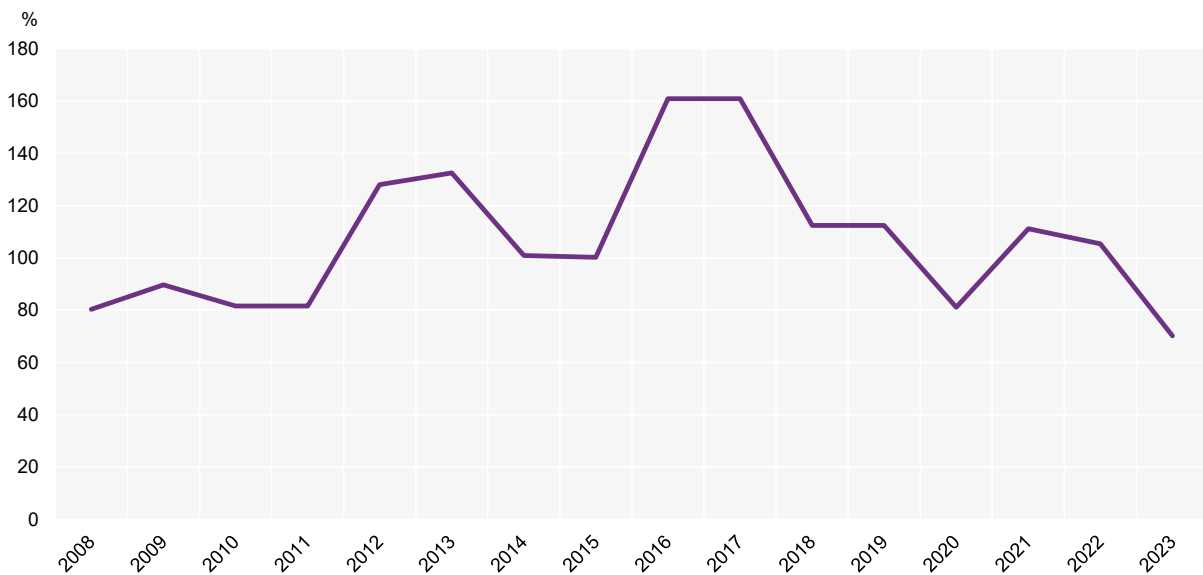
The performance of communication operators displays notable divergence across various indices. European operators experienced a decline of 47% from 1 January 2008 to 30 June 2023. Conversely, the MSCI World Telecom Services Index, encompassing developments in 23 developed markets, increased by 8%. Meanwhile, communication operators in the United States, as measured by the S&P Telecom Select Industry, rose by 33% over the past 15 years. In comparison, the broader stock market, represented by the MSCI World Index, experienced an overall growth of 87%, while the Dow Jones surged by 159% over the same period.

When it comes to dividends, communication operators have generally high pay-out ratios. This may play a considerable role in explaining the performance of shares of communication operators. A high pay-out ratio generally means that a significant portion of a company's earnings is distributed to shareholders as

dividends. Depending upon strategic priorities, this can mean that less money is available for reinvestment in the business or to fund growth initiatives. As a comparison with the five big technology companies examined in the subsection on these companies below, according to Bloomberg data, the pay-out ratio for Apple was 23.2% and for Microsoft 46.5% for the 2013-2023 period. Meta announced in February 2024 to distribute dividends for the first time (BBC, 2024^[6]). Amazon and Alphabet have not distributed any dividends.

Figure 15. Average pay-out ratios of European operators peaked at 161% in 2016 and 2017

Average pay-out ratios (fraction of net income paid out to shareholders) of 13 European operators, 2008 – 2022



Source: Adapted from Bloomberg (2023), Bloomberg Terminal, <https://www.bloomberg.com/professional/products/bloomberg-terminal> (accessed 15 September 2023)

Summary of financial performance of communication operators

Communication carriers exhibit on average stable profit margins as measured by EBITDA and EBIT. Nevertheless, ROIC has experienced a decline over time to reach 5% in 2022. For some markets, this could reflect increased competitive intensity. The convergence of ROIC levels of incumbents and challengers likely indicates the levelling effects of competition following the liberalisation of the communication sector. Variations in the cost of capital among companies and market conditions may also have played a significant role in shaping this scenario.

Recent increases in interest rates have added pressure to the cost of capital. The cost of capital for communication companies is intricately linked to their credit worthiness, which heavily depends on the strength of their balance sheets. The analysis reveals a rising trend in the net debt to EBITDA ratio for communication carriers, reaching 2.6 compared to 2.0 since 2018. This increase in debt can be attributed to easy access to low-cost capital and a willingness to take on debt in recent years. The divestment of towers and other infrastructure assets to tower companies contributed to the net debt increases in the infrastructure construction category. Cable & Satellite companies also experienced heightened leverage, with an average net debt to EBITDA ratio of 4.8. Credit rating institutes closely monitor these ratios, making companies vulnerable if they fail to generate sufficient cash flow to meet their debt obligations, which could lead to increased financing costs for new investments.

A pivotal metric for assessing the competitiveness of the market is ARPU. The GSMA Intelligence data reveals consistently higher ARPU levels in the United States and Canada in comparison to Europe. Notably, Europe and Asia Pacific witnessed a pronounced decline in ARPU over the last 15 years, while the United States and Canada experienced only a marginal decline. It is crucial to consider various factors such as services provided, data allowances, and exchange rate fluctuations when interpreting these ARPU variations.

The future of broadband networks largely hinges on continued investments. The capex-to-sales ratios, ranging from 15-20%, have been stable over time and have supported investments. However, the further growth of investments is contingent upon the development of revenues. While revenues measured in USD showed a decline in Europe, they increased in the United States, Canada and Latin America. Investments in absolute terms may not witness significant expansion if revenues stagnate or continue to decline. The declining ROIC further adds to the challenge of garnering support for additional investments, especially concerning a common managerial goal of maintaining shareholder values through comparatively high dividend yields. However, investment requirements differ between investor groups such as for example financial investors in wholesale infrastructure on the one hand and shareholders of listed communication operators on the other hand, as some infrastructure investors are accustomed to foregoing dividends for a period while expecting value upon exit. Others may demand a continuous flow of dividends to retain their shares. While small shareholders, for example, might seek a short-term boost in share price or prefer high dividends, some investors may strategically plan for the long-term growth and stable and sustainable but more moderate returns from wholesale or network businesses. It is important to acknowledge these different investment patterns when assessing longer term investment trends in the communication sector.

From a societal standpoint, securing future infrastructure investments and ensuring the maintenance of existing infrastructure is crucial. One factor to monitor in the future is the impact of higher financing costs given higher interest rates and the debt-load operators are willing to take which might increase overall risks for continued investments in infrastructure. Moreover, the evolution of ROIC and overall cost of capital are key factors which will influence the level of future investments.

Tower companies on the rise

As foreshadowed in the previous section, tower companies play an increasing role in investments in communication infrastructure. In addition, they allow traditional communication operators to offload investments needs in this part of the value chain. The OECD report “The Operators and their Future” (OECD, 2019^[1]) discussed a trend by mobile network operators (MNOs) to sell their wireless towers in full, or in part, to entrants in the communication infrastructure ecosystem. The arrangements involved a combination of MNOs and the new players entering long-term leases for the use of these passive facilities and, in the instances of partial sales, the creation of new companies jointly owned by both parties. This development has been reinforced. For well over two decades, MNOs in the United States, for example, had extended and augmented their coverage by renting space on towers owned by other companies. The companies emerging to serve the demand from MNOs were entities such as American Tower and Crown Castle, but these players were not created by MNOs. Mobile operators such as AT&T and Verizon predominantly used their own towers and had no ownership share in the companies providing this rented space.

In the first decade of this century, however, as MNOs introduced 3G technology and aimed at improving data services, they began to examine how they could share their own towers. In Sweden, operators established joint companies in 2001 in two different constellations to deploy common 3G radio access networks including towers.⁶ In the United Kingdom, this resulted in the first entities created under joint MNO ownership. In 2007, EE (owned by BT) and Three (owned by Hutchison 3G Enterprises S.A.R.L) formed Mobile Broadband Network Limited (MBNL) in the United Kingdom, to provide tower infrastructure,

with each company owning 50% of the venture (MBNL, 2023^[7]). Nonetheless, there were few players specialising in tower ownership and engaged in direct investment in such companies by private capital or pension funds.

The creation of ventures such as MBNL and successors was primarily aimed at cost reduction, as networks expanded with each generation of wireless technologies (i.e., 3G, 4G and 5G). At the time, and in subsequent years, there were discussions among industry regulators as to whether such ventures would detract from infrastructure competition. The question was asked as to whether MNOs would still seek to expand geographical coverage for competitive advantage if, for example, towers were shared. On the other hand, it was argued that benefits might be accrued in areas such as cost sharing or lower urban imprints, as networks became denser, which could result in better outcomes for all.

Yet, while tower sharing between MNOs spread to numerous other countries, this model has subsequently been overtaken by arrangements in which independent players from outside the traditional industry acquire tower and adopt open access models. Even MBNL is undergoing changes. In March 2023, it was announced that EE and Three were set to stop upgrading the other's sites (Telco Titans, 2023^[8]). The primary reason given for the changes, which aimed at more autonomy for each MNO, appear to have been longstanding differences in the establishment of new wireless sites.

Changing the communication stack?

If the first generation of tower arrangements were MNOs fully owning their own towers and the second generation shared, but fully owned and operated, towers, the third generation appears to be a separation – whether full or partial – of ownership and operation of towers. Indeed, and while noting MNOs often retain the right to establish new sites after selling their towers and becoming anchor tenants, many MNOs have fully sold their towers. Furthermore, a fourth model whereby tower owner companies expand their services to additional areas is rapidly emerging, raising the question of how the future ownership of 'communication infrastructure and associated software stacks' may evolve.

Not all MNOs sold their towers, even if they created a separate unit. One example of among the largest is Orange, which set up a standalone but fully owned unit called "Totem". Officially launched in November 2021, Orange said it hoped the new structure would enable the company to sell space on towers and other locations to rival operators. A year later Totem entered into such an agreement to lease towers across France to the Iliad Group (Free Mobile) (Mobile World Live, 2022^[9]). Moreover, as a standalone company, Totem begun offering distributed antenna system (DAS) infrastructure, with antennas designed specifically for sporting venues with high mobile phone 5G usage, to all four MNOs in France (Orange, 2023^[10]).

The other major MNOs retaining ownership of tower assets are in Canada. Canada's three largest MNOs (Bell, Rogers and Telus) own the bulk of the tower assets, with smaller regional providers continuing to build out their own infrastructure. With respect to tower sharing, the Department of Innovation, Science and Economic Development Canada (ISED) requires spectrum licensees who are communication common carriers – as a condition of their spectrum licences – to facilitate sharing of antenna towers and sites, and not cause or contribute to the exclusion of other carriers from gaining access. ISED's tower sharing framework also includes processes to request access to other operators' towers, and to engage in arbitration in the event of a dispute. However, there has been criticism from some smaller providers that sharing requests take too long to process and that the major MNOs have little incentive to co-operate.

Bell, Rogers and Telus may believe that in a country, with attributes such as a relatively low population density and requiring substantial financial outlays, their ownership enables strategic decisions to be taken to reward infrastructure investment. This may be why they chose to take a different path to MNOs in most other OECD countries in retaining full ownership. One independent tower company, which had 60 tower sites at the time of its acquisition by InSite Wireless Group (then American Tower), was SIGNUM Wireless.

Founded in 2011, and sold in 2020, SIGNUM Wireless said it was then one of only a handful of independent tower developers and owners in Canada. It gave as background at the time of sale:

“The Canadian communication infrastructure market is different from the United States. In Canada, tower assets are primarily built and tightly-held by the three major mobile network operators – Rogers, Bell, and Telus. Often, the only opportunity for independent tower developers to construct carrier-grade towers is in the so-called “network gap,” that is, in locations where the wireless carriers need a new tower but for various reasons, have not built one (Inside Towers, 2021^[11]).”

ISED’s tower sharing provisions were last updated in 2013, and further regulatory intervention by the Canadian Radio-television and Telecommunications Commission (CRTC) has helped to improve access to incumbent networks.

For instance, in 2015, the CRTC directed Bell, Rogers, and Telus to provide GSM-based wholesale roaming to other wireless carriers. The CRTC set interim rates in that decision and established the final rates in 2018. Shortly afterwards, the CRTC launched a review of mobile wireless services in 2019, which culminated in a decision that:

“...allows regional cellphone providers to compete as mobile virtual network operators (MVNOs) across Canada. Under this policy, large cellphone companies must share their networks with competitors. With access to larger networks, regional competitors will be able to offer cellphone services in parts of Canada that they do not currently serve (CRTC, 2023^[12]).”

This was followed, in May 2023, by the CRTC setting the final rules for this MVNO access:

“Companies have 90 days to negotiate MVNO access agreements. The CRTC expects that regional competitors will start selling plans in new parts of Canada shortly after these agreements are in place. The CRTC will ensure that deals are reached quickly so that Canadians have more choice of cellphone services (CRTC, 2023^[13]).”

Notably, the CRTC’s mandated MVNO model seeks to balance competition with investment by requiring that the smaller providers using the model hold spectrum at the Tier 4 level or higher, operate their own home network and by monitoring that they continue building out their own networks while accessing the networks of the major MNOs. The MVNO model is anticipated to be in place for seven years, after which it may be phased out and the smaller providers would have to start fully using their own networks. Accordingly, as of April 2023, it is too early to determine how the regulatory environment has and will impact tower ownership in Canada.

Why are MNOs selling towers?

No matter the structure chosen, nearly all MNOs are seeking to benefit from their past investment in passive infrastructure to raise capital or income streams. Some choose to sell full or majority stakes in their towers and become long-term tenants, some sell minority portions through taking on partners or stock market floats of spun-off units, and others simply create a separate unit to sell space to competitors. As is the case for communication operators, different types of owners may follow different businesses strategies that either focus on monetising or strategically developing their tower assets.

There are caveats to MNOs trying to benefit from past investments in passive infrastructure that reflect how important MNOs regard ownership of towers as a strategic asset or whether they feel their goals can be met through long-term leases and other specifications at the time of sale. Those taking the view that full or majority ownership still form an important point of leverage, followed that path. In one sense, this is a traditional communications operator position, which highly valued the control of as much network access to customers as possible.

Even some MNOs selling majority stakes in tower units took a cautious approach to the final transfer of ownership and to giving up commercial advantages they believe may be relinquished by fully opening

towers to competitors. In the case of Deutsche Telekom, for example, a majority stake in its tower unit (DTT) in Austria and Germany was sold in 2022. Nonetheless, at the time of sale, the company required in the agreement an option for it to purchase back the share after five years. In addition, in Germany some 10% of DTT locations were designated as “golden” sites, in prime locations, where secondary tenants were not permitted. Specifications such as these suggest some MNOs are willing to forego a higher upfront price in return for other strategic considerations as they place limitations on other owners.

More complex considerations can emerge in the ownership and sharing of towers at the time of transactions for MNOs, independent buyers and regulators. A case in point was the Australian Competition and Consumer Commission (ACCC)’s consideration of a regional network sharing arrangement by two MNOs (Telstra and TPG). TPG and Vodafone Australia completed a merger of their businesses in 2020. The intent to merge had been announced just prior to TPG entering the Australian market as the country’s fourth MNO. The merger had been unsuccessfully opposed by the ACCC, which warned it would lead to less competition and all the attendant effects that might be expected. This proved to be the case, with subsequent price rises, as monitored by the ACCC, in the following twelve months and one player raising prices by 20 percent for some plans in 2023 (ARN, 2021^[14]; Financial Review, 2023^[15]).

In the eighteen months after the merger of TPG and Vodafone Australia, the new company was planning its future network strategy, a key consideration of which was towers. As the third largest MNO, the merged entity had less coverage than Telstra and Optus in regional areas, but valuable spectrum inherited from both its predecessors. In early 2022, TPG announced it had struck an agreement with Telstra broadly summarised by the ACCC as follows:

“... the Proposed Transaction involves TPG authorising Telstra to use spectrum which it currently owns, and Telstra providing TPG with network services by way of active mobile network infrastructure sharing in certain regional and urban fringe areas (the Regional Coverage Zone), which comprise approximately 17% of the Australian population coverage. TPG will use the Multi-Operator Core Network (MOCN) services supplied by Telstra to offer 4G and 5G retail and wholesale services in the Regional Coverage Zone. TPG will also transfer up to 169 of its existing mobile sites in the Regional Coverage Zone to Telstra, and intends to decommission the remainder. The initial term of the MOCN Service Agreement is 10 years and TPG has two options to extend the agreement by 5 years. Under the Proposed Transaction, TPG and Telstra would continue to operate their own networks in metropolitan areas where around 81.4% of Australia’s population resides. TPG and Telstra would also continue to operate their own mobile core networks (both in and outside the Regional Coverage Zone).” (ACCC, 2022^[16])

While the ACCC acknowledged there were some potential benefits from the proposed deal, it ruled against it. This decision, unlike their earlier opposition to the merger between TPG and Vodafone, was subsequently upheld under judicial review (The Guardian, 2023^[17]).

The judicial ruling concurred with the ACCC that the agreement, which would have resulted in TPG decommissioning around 700 Vodafone mobile sites in regional areas, to instead use 3 700 Telstra mobile sites, could reduce infrastructure competition. While not being a ruling against future network sharing arrangements, it was determined the deal could substantially influence the incentives different players had to upgrade coverage in rural areas in the future, including because it involved both passive and active facilities (The Guardian, 2023^[17]).

A further complexity to the consideration of different players, during this period, was the sale or decommissioning of towers, in full or in part, by the Australian MNOs or other owners. For investors, in independent or newly created tower companies, the market structure in terms of how many MNOs there are in a country, is a potential consideration. For example, the number of players influences the number of potential MNO customers for open tower companies. As soon as the Telstra and TPG Telecom’s network sharing deal was announced, at the beginning of 2022, the Australian press promptly discussed its implications for the sale of Axicom, then the country’s largest independent tower company, which ultimately took place in April 2022.

While the proposed deal, between Telstra and TPG did not proceed, the structure of the proposal raises again the question of how the communication and software stack may develop. Primary among this question is how the tower companies will evolve, including where wholesale or MNO networks have financially underperformed against shareholder expectations. Will, for example, tower companies take a more active role in developing a greater degree of wholesale services and even ownership stakes in wholesale or MNO networks? Will some MNOs, through their ongoing shares in tower companies or units, access to spectrum and active facilities seek a different business model? In this respect, recent developments in Mexico and Italy are worthy of note (See Box 1).

Box 1. Tower companies developing increasing wholesale services in Mexico and Italy

Mexico was the first country in the world to launch a mobile wholesale network – the *Red Compartida* – aiming for an eventual population coverage of 92%. While meeting some network deployment targets in its first few years of operations, and attracting many MVNOs, the pace of expansion slowed as the operator endeavoured to further roll out towers and provide active facilities in underserved areas and the network did not manage to attract traffic from bigger network operators. Due to insufficient revenues, this led to Altán Redes, the private consortium developing the wholesale network, filing for bankruptcy in July 2021. During this period, it aimed to use protection under Mexican law to renegotiate its debt, something it achieved by the Mexican Government indirectly through development banks such as Banobras, Nafin and Bancomext, acquiring just over 60% of shares in 2022 (ITF, 2022^[18]).

In July 2023, the Federal Institute of Telecommunications (IFT), Mexico's communication regulator, authorised Macquarie Asset Management Mexico to take control of the administration of the 18.29% of Altán Redes shares held by the People's Republic of China (hereafter "China") - Mexico Fund GP. The Australian based Macquarie Group has owned tower companies in several countries in recent years, including its joint ownership with Digital Bridge, of Mexico Tower Partners (MTP).

MTP is the largest private owner and manager of wireless communication infrastructure in Mexico. The company owns, operates and manages a portfolio of more than 3 000 telecommunication towers distributed nationwide. MTP was founded in 2014 as the result of combining the Mexican cell tower portfolios of Digital Bridge and Macquarie Mexican Infrastructure Fund. The Altán Redes restructuring means that Macquarie becomes the first entity from a 'tower company' background to own and manage a wholesale mobile network with spectrum, active and passive facilities.

In contrast to Mexico, a recent restructuring in Italy involved an MNO moving towards a wholesale model. In May 2023, it was announced that EQT Infrastructure, a Swedish based financial asset manager, would acquire a 60% stake in a newly created company which will own and operate the Italian operator Wind Tre's mobile and fixed network. The transaction gives the new company an enterprise value of EUR 3.4 billion (USD 3.58 billion) (EQT, 2023^[19]).⁷ EQT said that the new company will provide wholesale connectivity services to Wind Tre and other Italian mobile operators, becoming the country's largest provider of mobile network coverage and capacity. Wind Tre's previous owner, CK Hutchison, remained as a part owner of the new entity with a 40% share.

In 2021, CK Hutchison had completed the sale of its tower assets in Italy, which had comprised around 9 100 cellular sites, to Cellnex. This suggests that EQT aimed to buy a different type of asset than Cellnex. In this respect, and setting aside any potential exuberance in language, the investment bank and financial services entities that facilitate such deals seem to agree. Citigroup worked with EQT and afterwards an executive from Citi said:

“This was a path-finder deal, a global first that saw a mobile network placed in independent hands. We were able to bring together our advisory and industry know-how to execute a type of deal that many had considered off limits and that makes me especially proud” (Capacity Media, 2023^[20]).

Benoit Hanssen, incoming CEO of the new entity said it is “one of the first independent multi-tenant radio access network owners and operators globally (EQT, 2023^[19]).” More specifically:

“Following the carve-out from the Italian telecommunication provider Wind Tre, the Company will own and operate the country’s largest mobile network and a portfolio of assets, including radio antennas, base stations, transport network and associated contracts. The Company will be the first independent access network in Europe primarily focused on mobile and dedicated to the provision of wholesale services to mobile operators through its state-of-the-art network, which at the end of 2022 covered approximately 67 percent of Italy with 5G reception (EQT, 2023^[21]).”

EQT’s other major investment in this sector in 2023 was its purchase, together with Public Sector Pension Investment Board (“PSP”), of Radius Global Infrastructure for approximately USD 3 billion (EQT, 2023^[21]). Radius owns and acquires critical digital infrastructure, including ground, tower, rooftop and in-building cellular sites, in over 20 countries across North and South America, Europe, and Australia. Radius’ portfolio of approximately 9 000 leases across nearly 7 000 sites serves more than 200 customers (see also “Financial asset managers shaping the connectivity ecosystem”).

What is the attraction for independents tower owners?

One of the attractions to the mobile tower market for independent players, such as tower companies and financial asset managers, is the perception of long-term stability and predictable ‘utility like’ returns. Mobile networks have been established over decades and in many instances the locations and infrastructures are challenging to duplicate for economic or aesthetic reasons. Changes in market structures are one potential unknown as is the financial performance of client MNOs. In India, for example, the poor financial position of Vodafone Idea has resulted in faltering payments to one tower company and the potential market exit of another of which it is its major customer (DCD, 2022^[22]; DCD, 2023^[23]). These instances, however, are rare.

Few could have predicted the loss of market share experienced by Vodafone Idea and other Indian MNOs after the 2015 launch of Reliance Jio Infocomm Limited. Jio quickly became the mobile market leader in that country based on a combination of low prices and other innovation (Reuters, 2023^[24]). In 2020, the company then sold one of the world’s largest network of towers – built to facilitate its market entry – and became its anchor tenant.

An entity involved in the purchase of the Jio towers was Brookfield, one of the world’s largest infrastructure investors. Brookfield’s description of its business is emblematic of the attractions the tower market has for such players:

“We own and operate assets across the transport, data, utilities, and midstream sectors with a focus on cash flow stability and resilience. Our portfolio ... provides diversified exposure to scarce, high-quality businesses with significant barriers to entry (Brookfield, 2023^[25]).”

The OECD report “Communication Operators and their Future” (OECD, 2019^[1]) provided an extensive list of selected wholesale-only wireless tower and DAS operators. This included firms such as American Tower, Cellnex, Crown Castle, SBA Communications and Tillman Infrastructure, as well as a group of investment or private capital companies such as Brookfield, KKR and the Canada Pension Plan Investment Board. Some of these latter players had created their own tower operators or jointly invested in tower companies spun off from different MNOs.

If the third phase of tower operation and management was the separation of the MNO from passive infrastructure, the fourth may be defined by even less integration of communication companies. These companies are sometimes United States listed real estate investment trusts (“REIT”) (Nareit, 2021^[26]). These companies operate on a familiar business model in property markets by leasing space and collecting rents. Other tower companies are privately owned though have a similar business model. On the space they rent from REITs or the like, MNOs continue to manage and maintain their active facilities but tower companies are increasingly buying or partnering with data centre companies to provide services collocated or connected with their own high-speed fibre networks. Examples include American Tower’s acquiring of CoreSite; Cellnex buying Alticom, a Dutch company with data sites; and Brookfield partnering with Digital Bridge in tower investment. Cellnex summarises how its business is changing:

“Cellnex have evolved from the pure InfraCo concept to the Augmented Tower concept, a disruptive transformation in the model under which we manage our assets: from pure co-location services to a complete Site as a Service offering, (i) An Augmented TowerCo is capable to bring high bandwidth connectivity to their sites, (ii) Augmented Towers are sustainable sites, that combine traditional energy supply with green energy sources that make energy cost in a site the most efficient ever (iii) traditional shelters in a tower become Edge Datacentres under the Augmented TowerCo model (Cellnex, 2023^[27]).”

To support multiple tenants with edge computing and fibre connectivity to data centres, tower companies are filling some roles that may once have been played by communication operators. Most obvious is the fibre networks connecting towers to data centres or other traffic exchange facilities. Sometimes this is done in partnership with MNOs, such as is the case in France between Cellnex and Bouygues Telecom in the joint creation of a company to provide both fibre transport networks (backhaul and backbone) and edge computing centres (Cellnex, 2020^[28]). In this case Bouygues Telecom is expected, as anchor customer, to provide 80% of the business while business such as American Towers aim at sales to all MNOs. A snapshot of the transactions around towers and tower investors since the previous OECD report (2019) is provided in Annex 1.B.

The expanding role of big technology companies in financing communication infrastructure

Big technology companies (“tech companies”) have developed into some of the largest enterprises in the world. In addition, they are leaders in research and development (R&D) expenditure. Apart from their respective core businesses, tech companies often build their own communication infrastructures. To date, however, they have largely not become Internet service providers (ISPs). This suggests that while they are extremely effective competitors in several fields, such as over-the-top (OTT) services, traditional access operators maintain advantages in providing broadband access (OECD, 2019^[1]).

Tech companies take on different roles in the connectivity ecosystem, including roles such as content and application provider (CAPs), content delivery network (CDN) provider, data centre provider and cloud provider, and provide a variety of services. In addition, tech companies have increased their investment in fibre backbone and access networks, as well as submarine cables, in recent years. According to Analysys Mason, CAPs spent USD 883 billion on communication infrastructure from 2011 to 2021⁸. The average annual amount of infrastructure investment by CAPs exceeded USD 120.1 billion between 2018 and 2021. This investment can be broken down into hosting (i.e. data centres) with USD 112.5 billion, transport with USD 4.5 billion (i.e. submarine and terrestrial cables) and delivery (i.e. peering and caching) with USD 3.1 billion (Analysys Mason, 2022^[29]).

The examples shown in the boxes of this section focus on the five biggest publicly listed technology companies in terms of market capitalisation in OECD countries. As of February 2023, these are Apple (2.29 USD trillion), Microsoft (1.84 USD trillion), Alphabet (referred to as “Google” in the following, 1.29 USD trillion), Amazon (1.05 USD trillion), and Meta (390.62 USD Billion) (investingnews, 2023^[30]).

Data centres and cloud infrastructure

Besides investments in communication infrastructures, tech companies have been building large data centres around the world, some of which they connect with dedicated private submarine and terrestrial cables. Tech companies not only host data for their services, but also third parties. In addition, tech companies have increased their edge computing and cloud service offers (OECD, 2022^[31]). According to Analysys Mason, between 2018 and 2021, CAPs spent 94% of its communication infrastructure investments on data centres (Analysys Mason, 2022^[29]). According to a report by Dell'Oro Group, global data centre capital expenditures grew by 15% to USD 241 billion in 2022 (Dell'Oro, 2023^[32]).

Global spending on cloud infrastructure services (including infrastructure as a service (IaaS), platform as a service (PaaS), and hosted private cloud services) amounted to more than USD 63 billion in Q1 of 2023. This represents an increase by more than USD 10 billion compared to Q1 of 2022. Amazon (AWS), Microsoft (Azure), and Google (Google Cloud) are key players, each holding significant market shares of 32%, 23% and 10%, respectively (Synergy Research Group, 2023^[33]).

Box 2. Selected tech company investments in cloud infrastructure

Amazon, Google, Microsoft, Meta and Apple investments in cloud infrastructure

The AWS Cloud spans over 102 zones within 32 regions⁹ around the world, with announced plans for twelve more zones and four more regions in Canada, Malaysia, New Zealand and Thailand as of August 2023 (AWS, 2023^[34]). Amazon has announced numerous investments in data centres. Major examples include investments amounting to USD 7.2 billion in Israel (Amazon, 2023^[35]), USD 4.5 billion in Australia (Amazon, 2023^[36]), USD 6 billion in Malaysia (Amazon, 2023^[37]), USD 4.4 billion in India (Amazon, 2022^[38]), USD 2.5 billion in Spain (Amazon, 2022^[39]), USD 5.9 billion in Switzerland (Amazon, 2022^[40]), USD 5 billion in Thailand (Amazon, 2022^[41]) and USD 5 billion in the United Arab Emirates (Amazon, 2022^[42]). In the United States, recent main investments are USD 7.8 billion in Ohio (Amazon, 2023^[43]), USD 35 billion in Virginia (Amazon, 2023^[44]) and USD 15.6 billion in Oregon (Amazon, 2023^[45]).

Google owns and operates 24 data centres around the world, including 14 in North America, one in South America, six in Europe and three in Asia as of August 2023 (Google, 2023^[46]). These data centres support Google Cloud in 37 regions and 112 zones (Google, 2023^[47]). New regions were recently opened in Qatar (Google, 2023^[48]), Italy (Google, 2023^[49]) and Israel (Google, 2022^[50]), and Google expects that these investments will increase GDP in the countries by USD 18.9 billion, USD 3.5 billion (EUR 3.3 billion) and USD 7.6 billion, respectively. Google announced that it will continue to expand in the following regions: Berlin (Germany), Dammam (Kingdom of Saudi Arabia), Querétaro (Mexico) and countries: Austria, Greece, Malaysia, New Zealand, Norway, South Africa, Thailand and Sweden (Google, 2023^[47]).

Azure from Microsoft is available or being made available in over 60 regions, distributed across the United States, Americas, Europe, Asia Pacific, Middle East and Africa. Azure operates over 300 physical data centres (Microsoft, 2023^[51]). Microsoft announced in 2021 that it will add 50 to 100 new datacentres each year for the foreseeable future (Microsoft, 2021^[52]). Microsoft invested USD 12 billion in data centres in Europe from 2020 to May 2022 (Microsoft, 2022^[53]) and announced a new investment of AUD 5 billion (USD 3.5 billion)¹⁰ to its cloud computing and AI infrastructure in Australia over 2024 and 2025 (Microsoft, 2023^[54]).

Meta has a total of 21 data centres in Asia, Europe and the United States. The data centre in Asia is located in Singapore, where over SGD 1.4 billion (USD 1 billion) has been invested.¹¹ In Europe, Meta has three data centres located in Denmark, Ireland and Sweden, where over DKK 13 billion (USD 1.8

billion)¹², EUR 1.4 billion (USD 1.47 billion)¹³ and SEK 8.7 billion (USD 860 million)¹⁴ has been invested, respectively. In the United States, Meta established data centres in 17 locations, with a total investment of more than USD 22.15 billion (Meta, 2023^[55]).

Apple operates eight data centres as of September 2022, located in the United States, Denmark and China. Additionally, two more data centres are under development by Apple, in the United States and Europe, which would bring the company's total portfolio to ten upon completion. Apple's total investment in data centres amounts to over USD 12 billion in the United States and Europe (Dgtl Infra, 2022^[56]).

Tech companies have further made investments to enhance Internet protocol (IP) interconnection to ensure efficient and stable data delivery from their data centres to end users. This includes improving interconnection through peering agreements and increasing and enhancing caching infrastructure and CDNs in collaboration with communication operators and other partners. Caching technology plays a vital role in bringing data closer to users, reducing latency, ensuring high availability of service, and enhancing digital security against network attacks.

Two key types of IP interconnection, transit and peering, may be distinguished. Transit involves commercial contracts where one network operator pays another for access to the Internet. Peering represents network agreements where two entities exchange traffic directly. Tech companies engage in peering with various ISPs, enabling direct and more efficient content delivery that reduces reliance on upstream ISPs. This is achieved through private and public peering, with global Points of Presence (POPs) and routing equipment.

CDN providers typically offer commercial services, while tech companies often own CDN edge servers in their POPs and operate CDN services for their own and third parties. Moreover, some tech companies have partnered with ISPs to locate caching infrastructure within ISPs networks.

Box 3. Selected tech company investments in POPs and CDNs

Amazon, Google and Microsoft investments in data delivery

Tech companies have deployed Points of Presence (POPs) globally, peered with ISPs, built their own CDNs and offered CDN services to third parties. Amazon CloudFront peers with thousands of Tier 1/2/3 communication carriers globally and has hundreds of terabits of deployed capacity. CloudFront edge locations are connected to the AWS Regions through the AWS network backbone (AWS, 2023^[57]). To deliver content to end users with lower latency, Amazon CloudFront uses a global network of over 450 POPs and 13 regional edge caches in over 90 cities across 49 countries (AWS, 2023^[34]). Google operates a large, global meshed network that connects edge POPs to data centres. Google's edge POPs are present in over 200 IXPs and at over 100 interconnection facilities around the world (Google, 2023^[58]). In addition, Google provides Cloud CDN and Media CDN services to third parties. (Google, 2023^[59]). The company also provides ISPs with a Google Global Cache (GGC) that serves specific Google content from within the ISP's network. Static content which is popular with local users, such as YouTube and Google Play content, is temporarily cached in edge nodes within ISPs, reducing traffic between the ISPs and Google (Google, 2023^[60]). As for Microsoft, the company has deployed global network edge nodes within over 4 000 ISPs. In addition, Microsoft has operated CDN services called Azure Front Door and Azure Content Delivery Network linked to its cloud network. Microsoft has 192 POPs across 109 metropolitan areas (Microsoft, 2023^[61]).

Network infrastructure and cloud solutions

Communication operators are not the only companies invested in terrestrial and subsea backbone infrastructure. Over several years, tech companies made important investments in submarine cables, both for general Internet data traffic between countries, but also for data traffic between their data centres and POPs. While tech companies had accounted for less than 10% of total capacity prior to 2012, their share surged to 69% in 2021. They accounted for 92% of used capacity on the trans-Atlantic route in 2021, compared with just 21% on the Europe-East Asia route in 2021 (TeleGeography, 2021^[62]) (TeleGeography, 2022^[63]). For tech companies, owning subsea cables may be perceived as a competitive advantage. While largely dominated by communication operators in the past, the number of cases of submarine cables deployed by consortiums including tech companies has been increasing mainly across the Atlantic and Pacific. In addition to investments as part of consortiums, cases where tech companies finance submarine fibre cables on their own have been increasingly emerging in recent years. Almost half of trans-Pacific cable investments coming into service between 2023 and 2025 are supported and funded by tech companies (Table C.1. in the Annex 1.C) (TeleGeography, 2022^[63]).

Box 4. Selected tech company investments in submarine fibre cables

Amazon, Google, Microsoft and Meta investments in submarine fibre cables

Tech companies strongly invest in new submarine cable systems as well as backbone infrastructure that connects their global data centres. According to TeleGeography, as of October 2023, tech companies were involved in 38 submarine cable projects (TeleGeography, 2023^[64]). Tech companies own 35 cables, excluding capacity purchases in other cables, of which ten cables are owned solely or are jointly owned by only tech companies. Among these ten cables, excluding Junior, a small 390 km cable constructed in Brazil in 2018, the remaining nine cables were all constructed after 2021. From 2021, there is a clear trend towards 100% ownership of new cables with about 50% of the cable being solely owned by one tech company or jointly owned by tech companies only (see Table C.1 in Annex 1.C for a full list).¹⁵

Google, for example, has been involved in the construction of 22 submarine cables since 2010. It is notable that Google owns six long-distance cables between major continents, including Curie and Firmina in South America, Dunant and Grace Hopper connecting Europe and America, Topaz and TPU in the Pacific, and Equiano in Africa. Google announced in 2022 that it planned to invest USD 1 billion in Africa over the subsequent five years, including supporting startups and building a new subsea cable, Equiano, connecting Africa and Europe (Google, 2022^[65]). According to Google, this might lead to a 21% reduction in Internet prices, increase broadband speed in Nigeria and almost triple speed in South Africa (TechCrunch, 2021^[66]).

Meta was involved in the construction of 16 submarine cables, of which 14 are co-owned and one, Anjana, solely owned. Anjana is a high-capacity cable that will be built across the Atlantic and have a total theoretical capacity of 480 Tbps (Dgtl Infra, 2023^[67]). In addition, the cables Echo and Pacific Light Cable Network (PLCN), which cross the Pacific, are jointly owned with Google. Microsoft was involved in the construction of six submarine cables and co-owns four of them, including Amitie, SeaMeWe-6 and MAREA in the Atlantic, and New Cross Pacific (NCP) Cable System in the Pacific. Amazon has been involved in four submarine cable projects. The company is a major capacity buyer for three of them and constructed the JUPITER cable, which crosses the Pacific, with a consortium.

Access network infrastructure has traditionally been deployed and operated by communication operators. Tech companies are often leasing access to dark fibre based on long-term agreements. Dark fibre leases continue to grow as they allow for rapid expansion of capacity and greater cost certainty over time. In

addition, tech companies also often invest directly in access network deployment in certain regions, usually in partnership with a backbone provider (Analysys Mason, 2022^[29]).

Box 5. Selected tech company investments in access networks

Amazon, Google, Microsoft and Apple investments in access networks

In some regions, tech companies commenced investing in or providing access services. For example, Google deployed fibre lines in some areas in the United States and provides its services as "Google Fiber". Its coverage was initially limited, but in 2022 Google announced a strategy to expand to new states for the first time in five years and to expand further in the future (Google, 2022^[68]).

Meta invests in Open Transport Networks (OTNx), which provide fibre backhaul for network operators. Meta deployed fibre through OTNx in Indonesia, Uganda, Nigeria and South Africa. The investments in Indonesia are expected to help bring 900 000 people online and generate over USD 6 billion in GDP between 2020 and 2024 (Meta, 2020^[69]). In addition, Meta announced a partnership with Liquid Intelligent Technologies to build an extensive long-haul and metro fibre network in the Democratic Republic of Congo. The new fibre network will help connect East and West Africa by land and is expected to improve Internet access for more than 30 million people to help meet growing demand for regional connectivity across Central Africa (Connecting Africa, 2021^[70]).

Moreover, in recent years tech companies have also entered the satellite communication technology market for the provision of backhaul and access networks. While SpaceX's Starlink is the largest provider of low Earth orbit (LEO) satellite services with 4 830 working satellites in orbit as of October 2023 (Planet 4589, 2023^[71]), Amazon's Project Kuiper will also deploy LEO satellites, linked to a global network of antennas, fibre and internet connection points on the ground (Amazon, 2023^[72]). Microsoft announced a new partnership with Viasat to help deliver Internet access around the globe, including five million accesses across Africa in 2022. The companies will collaborate to provide and pilot technologies including satellites (both geostationary orbit and LEO) and fixed wireless (Microsoft, 2022^[73]). Apple announced in 2022 a USD 450 million investment from their Advanced Manufacturing Fund to provide emergency SOS services via satellite for iPhone 14 models. A majority of the funding goes to Globalstar, a global satellite service (Apple, 2022^[74]).

Tech companies and communication operators are furthermore increasingly working together with respect to recent trends such as the virtualisation of networks and the integration of cloud services into communication networks. Some tech companies have been providing cloud technology services to communication operators. Typical examples of integration of cloud solutions in networks are an increased use of the cloud in the core network and the provision of cloud edge computing solutions (OECD, 2022^[31]).

Box 6. Selected tech company service offering in cloud solutions for communication operators

Amazon, Google and Microsoft investments in cloud solutions

In 2021, AWS announced a strategic collaboration with Dish, a greenfield communication carrier in the United States who has built a cloud-based 5G network on the AWS cloud infrastructure (Dish, 2021^[75]). Swisscom has been building a 5G-stand-alone (SA) core network using AWS's public cloud (Fierce Wireless, 2023^[76]). In addition, Amazon announced the AWS Telco Network Builder in 2023, which is a fully managed service that helps communication operators deploy, run and scale cloud-native networks (AWS, 2023^[77]). Microsoft has provided Azure for Operators since 2020 (Microsoft, 2023^[78]). Microsoft and AT&T announced the acquisition of AT&T's network cloud platform technology by Microsoft Azure in 2021, and AT&T's core network was to be moved to Azure for Operators (Microsoft, 2022^[79]). In 2023, Microsoft announced the Azure Operators Nexus, a cloud platform for communication operators (Microsoft, 2023^[80]). As for Google, communication carriers can manage and operate networks on the Google Cloud by utilising Google Distributed Cloud Edge (Omdia, 2022^[81]). In 2023, Google also announced new solution products for communication operators such as Telecom Network Automation (Google, 2023^[82]), Telecom Data Fabric (Google, 2023^[83]) and Telecom Subscriber Insights (Google, 2023^[84]). Operators such as Airtel, AT&T, Bell Canada, Deutsche Telekom, Jio, Orange, Telus and TIM are already working with Google Cloud (Omdia, 2022^[81]).

Financial asset managers shaping the connectivity ecosystem

Financial asset managers, such as private equity firms, hedge funds or pension funds, are playing an increasing role in providing funding for communication infrastructure and services. Large parts of these funds invest in fibre wholesale access networks, not only changing the structure of the connectivity ecosystem, often in rural and remote areas, but also the overall composition of investments going into the deployment of broadband networks. Since the global financial crisis, private equity firms, for example, have provided an estimated 10% of all infrastructure financing (Moonfare, 2022^[85]; Preqin, 2020^[86]). In 2020, financial transactions in communication infrastructure and services accounted for 35% of total private equity infrastructure deal value, up from 15% in 2019 (S&P Global, 2021^[87]). As of March 2021, a total of 528 funds with exposure to communication infrastructure and services were in the market to raise a combined targeted capital of USD 155.1 billion (S&P Global, 2021^[87]). While not splitting out categories, Bain & Company calculated the total value of private investments and trading in the communication sector to be USD 35 billion in 2021 and USD 32 billion in 2022. In their 2023 report on Mergers and Acquisition, Bain & Company noted (Bain & Company, 2023^[88]):

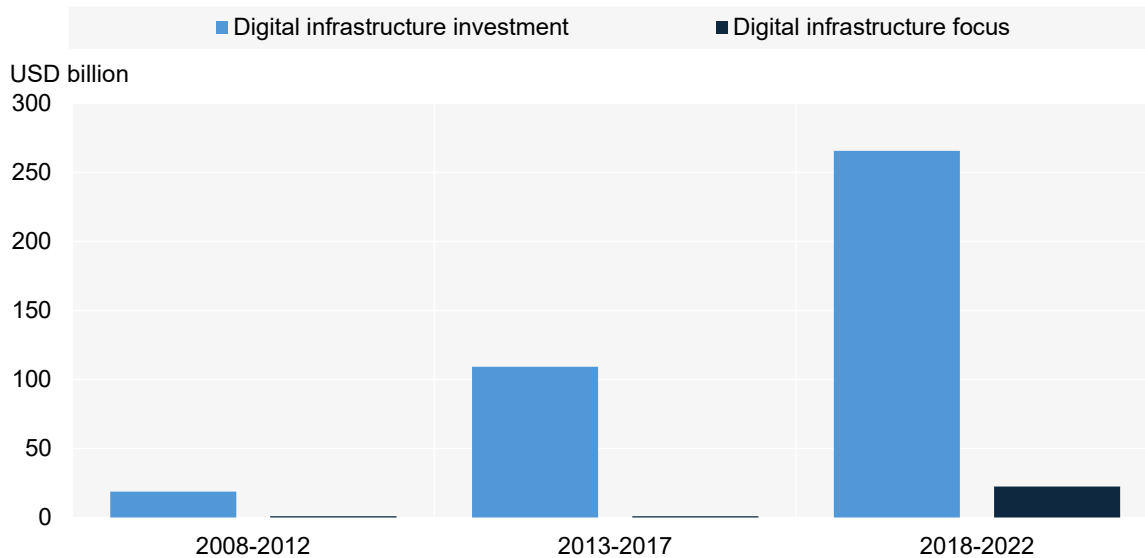
“Digital infrastructure deals will continue despite the rising cost of debt. That activity is propped up by the available dry powder of longer-term investors, strong underlying demand trends, government support, and the many high-quality tower and fibre assets that are still expected to come to market. Tower deals performed particularly well during the last half of 2022 despite the higher cost of debt. High digital infrastructure investor demand will create a wave of particular interest in data centres.”

Capital raised by private equity funds focused solely on communication infrastructure has experienced significant growth over the past decade. Specifically, for the largest 20 funds investing in communication infrastructure, there was an almost sixfold increase in capital raised during the 2013 to 2017 period compared to the preceding one. In the 2018 to 2022 period, capital raised more than doubled in comparison to the previous period. The largest 20 funds *exclusively* dedicated to communication infrastructure saw a substantial rise in capital commitment. In the 2018 to 2022 period, these funds secured USD 22.6 billion in investments, a stark contrast to the USD 1.1 billion and USD 1.0 billion committed in the 2008 to 2012

and 2013 to 2017 periods, respectively. It is worth noting that although there is increasing interest in communication infrastructure, the field appears to be concentrated among a few major players.

Figure 16. The largest 20 funds exclusively dedicated to communication infrastructure secured USD 22.6 billion in the period of 2008 – 2022

Capital raised in USD billion by private equity funds in the top 20 raised annually that invest in communication infrastructure (divided into five-year brackets)

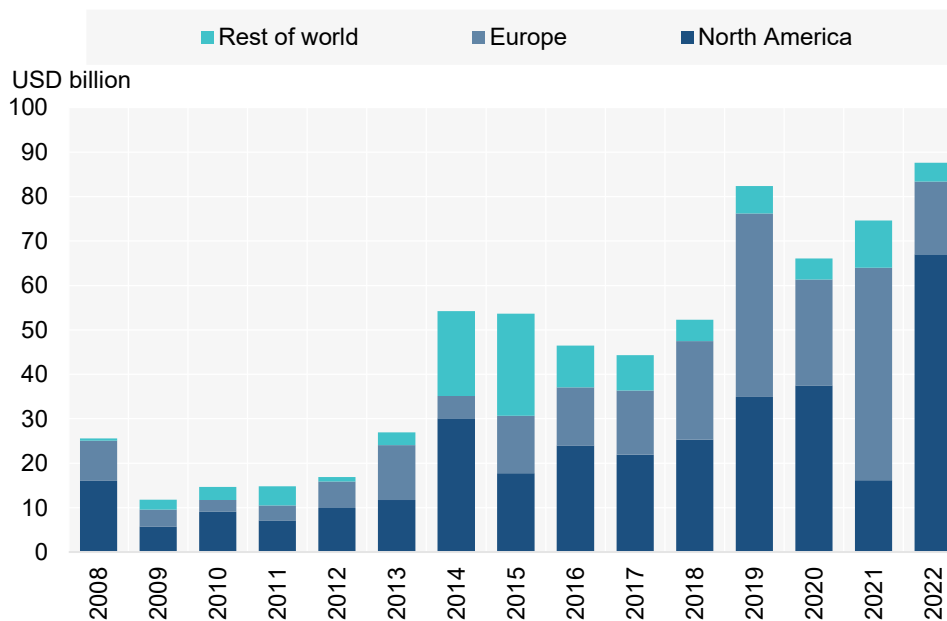


Note: Data for 2022 as of September 2022. Data also includes data centre-investing funds.

Source: PitchBook (2023), Sustainable and Digital Infrastructure in the Private Markets, <https://pitchbook.com/news/reports/q1-2023-pitchbook-analyst-note-sustainable-and-digital-infrastructure-in-the-private-markets>

Figure 17. Raised capital by funds investing in communication infrastructure have seen a strong positive trend between 2008 and 2022

Communication infrastructure capital raised in USD Billion by region



Note: Data for 2022 as of September 2022. Data also includes data centre-investing funds.

Source: PitchBook (2023), Sustainable and Digital Infrastructure in the Private Markets, <https://pitchbook.com/news/reports/q1-2023-pitchbook-analyst-note-sustainable-and-digital-infrastructure-in-the-private-markets>

Expansionary central bank policies, such as low interest rates, combined with high global savings may have incentivised financial asset management companies to look for long-term investments with stable and attractive “risk-return” patterns in communication infrastructure (European Commission, 2022^[89]). While the recent period of low interest rates led to a highly liquid market, investments into broadband infrastructure may have been especially catalysed by outlooks on the accelerated digitalisation brought by the COVID-19 health crisis. For example, McKinsey found in a survey of executives that companies accelerated the digitalisation of their customer and supply-chain interactions and of their internal operations by three to four years (McKinsey & Company, 2020^[90]).

Private equity companies, which usually take a long-term view on investments, may find the communication sector attractive as it usually entails high fixed costs and barriers to entry, which may result in predictable revenues. Moreover, the demand for communication services is relatively insensitive to economic shocks and price increases. Furthermore, given the long-term nature of investments in infrastructure, these may be a good match for defined-benefit pension liabilities, endowment and foundation obligations, and annuity and life insurance liabilities (JPMorgan Chase & Co, 2009^[91]).

Financial asset managers are increasingly investing in the tower company and Distributed Antenna System (DAS) markets. Funds investing include those managed, for example, by Brookfield, the Macquarie Group, KKR and the Canada Pension Plan Investment Board. Some investment funds have created their own tower operators. Others have taken major ownership stakes in tower players created by MNOs (OECD, 2019^[1]). A snapshot of transactions involving towers and tower investors (Table B.1 in the Annex 1.B) shows that there are many sovereign wealth funds, pensions or private equity funds entering the tower company market. In terms of sovereign wealth funds, those of Australia (The Future Fund) and Singapore (Government of Singapore Investment Corporation, GIC) have invested in tower companies, as have

government related pension funds such as the Public Sector Pension Investment Board (PSP), one of Canada's largest pension investment managers. As for private equity funds, investment in tower companies came from the Carlyle Group and Ardian. There are many more such as InfraRed Capital Partners, part of the Sun Life insurance group, Cordiant Digital (the first "digital infrastructure" fund to list on the London market, in February 2021) and Northleaf Capital Partners of Canada. In addition, long standing players that have been investing in communication infrastructure are increasingly looking towards tower companies. For example, KKR has expanded its investment in tower companies in Europe and, through its backing of Pinnacle Towers, in Asian countries (e.g. Bangladesh and the Philippines).

Ontario Teachers' Pension Plan and Alecta, which manages the occupational pensions of 2.6 million private individuals and 35 000 companies in Sweden, are investors in new tower ventures. Meanwhile, Australian superannuation funds are investing in tower companies in that country and, in the case of UniSuper, buying a 5% stake in European based Vantage Towers (Wiggins, 2023^[92]). In combination, players such as KKR (private investment), GIP (sovereign wealth fund) and UniSuper, through entities as Vantage Towers, aim to open towers to new colocation customers beyond anchor tenants. Vantage Towers aims to "expand the company's activities beyond its core business into fast-growing adjacent markets such as 5G private networks, data centres, edge computing, small cells and the Internet-of-things ("IoT") and deploying fibre to the tower ecosystem" (Wiggins, 2023^[92]).

The optimism for growth in new wireless services for private investors remains robust in open communication infrastructure, however, currently with a focus on passive infrastructure. In fixed markets, the interest shown by KKR, other investors and networks as well as, the Italian Government in Telecom Italia's NetCo provides a case in point (Lipscombe, 2023^[93]) (See Tower companies on the rise).

Private equity companies have also placed investments in spectrum. For example, private investment company Grain Management, founded by David Grain, former Senior Vice President of AT&T, specialises in communication infrastructure investments including fibre networks, cell towers and spectrum. Through its bidding vehicle for the 3.7 GHz to 4.2 GHz spectrum frequency band (also referred to as "C-Band"), NewLevel II, a portfolio of spectrum licenses, bid the fifth-highest amount in the spectrum auction in the United States (i.e. USD 1.277 billion for ten licenses) (RCR Wireless, 2021^[94]). In Brazil, Patria Investments, a company specialised in alternative asset management in Latin America, created a mobile infrastructure company called Winity Telecom and acquired 10 MHz in the 700 MHz band nationally in the 2021 Brazilian spectrum auction for USD 300 million in grants and USD 560 million in infrastructure construction obligations. However, in February 2024, Winity decided to relinquish the frequency grants after failing to secure an anchor agreement with Telefónica due to Anatel's competitive requirements.

As seen in the section "Tower companies on the rise", financial asset managers have also entered the market of mobile wholesale networks to some extent. In addition, some have been very engaged in investing in fixed wholesale fibre access. This is, for example, the case in Latin America. In Brazil, V.tal is perhaps the most advanced of the active neutral fibre networks in the region, having reportedly signed contracts with more than 400 ISPs. Brazilian bank BTG Pactual, through two funds, owns a 68.8% stake in V.tal (bnamericas, 2023^[95]). Other examples of fixed wholesale investments in Latin America include On net Fibra in Colombia and Chile. Canada's Pension Plan Investment Board agreed to pay USD 462 million for a 9.5% stake in V.tal in November 2022 (Data center dynamics, 2023^[96]). V.tal connects more than 2 380 municipalities in Brazil and owns more than 26 000 km of subsea cables that connect Brazil to Argentina, Chile, Venezuela, Colombia, Bermuda and the United States. V.tal also owns edge data centres distributed between Brazil and Colombia (V.tal, 2023^[97]).

While most of the above-mentioned examples refer to more advanced projects, financial asset providers invested and continue to invest increasingly in greenfield projects, i.e. deploying infrastructure from the ground up. This has been especially the case for data centres and fibre wholesale access networks. For example, asset manager EQT's portfolio companies are investing a total of USD 18 billion globally between 2021 and 2025 into new greenfield fibre network deployments and upgrades of existing network

infrastructure, of which roughly 50% are focused on B2B and inter data centre connectivity, and the remainder on deployments of fibre access networks. The company states that the future component of this capex deployment is contingent on a re-evaluation of project profitability meeting minimum return hurdles in the light of sharply rising interest rates and inflation in capex costs. In general, while ongoing projects are usually largely hedged, there is a possibility that increasing interest rates may reduce the addressable project base due to higher incremental cost of debt financing, but overall effects have yet to be seen.

Public financial support for broadband networks of the future

Public financial support continues to play an important role in broadband deployment. Since the COVID-19 health crisis, many OECD countries have introduced recovery packages, some of which are devoted to broadband network deployment. While this wave of public funding underlines the importance of communication infrastructure on the agenda of policy makers, the question is *how* countries have decided to boost inclusive access to high-quality connectivity.

Public funding may serve a variety of purposes, including to address market failures stemming from environmental externalities, other externalities or policy measures (IMF et al., 2022^[98]). While recovery from the COVID-19 health crisis may be categorised as a type of short to medium-term goal, OECD countries also invested various public funds for the deployment of broadband to bridge connectivity divides with a long-term perspective of addressing geographic and socioeconomic differences. Moreover, in recent years, promoting the environmental sustainability of communication networks has become increasingly important, which adds an additional perspective to public funding for broadband networks.

Recovery plans following the Covid-19 health crisis

COVID-19 recovery programmes in the OECD have focused on enhancing connectivity infrastructure, with a focus on fibre and 5G, in countries like Canada, the European Union, France, South Korea, the United States and the United Kingdom (OECD, 2022^[31]). For example, the European Union launched a recovery programme and each member state made various investments based on the programme. The *EU Recovery and Resilience Facility (RRF)*, as part of the *NextGeneration EU programme*, a EUR 806.9 billion (USD 954.9 billion¹⁶) temporary recovery instrument, makes available EUR 723.8 billion (USD 856.6 billion) in grants and loans for public investment and reforms in the 27 member states (European Commission, 2021^[99]). Reforms and investments aimed at improving connectivity are encouraged to be included in the *Recovery and Resilience programme (RRP)*. As of January 2023, 21 member states included them in the RRP. These reforms and investments amount to EUR 16.5 billion (USD 17.3 billion)¹⁷, representing approximately 3.3% of the estimated total RRF spending of the 26 approved RRP's and 12% of the estimated total digital spending (European Commission, 2023^[100]). For example, Italy published the *National Recovery and Resilience Plan* ("Piano Nazionale di Ripresa e Resilienza", PNRR) in 2021. The plan envisages investments and a consistent reform package, with EUR 191.5 billion (USD 226.6 billion) in resources being allocated through the RRF and EUR 30.6 billion (USD 36.2 billion) being funded through the Complementary Fund established by the Italian government. PNRR allocated EUR 6.7 billion (USD 7.9 billion)¹⁸ to projects forming the *National Ultra-Broadband Strategy* ("Strategia per la Banda Ultra Larga") announced in 2021 (Dipartimento per la Trasformazione Digitale, 2022^[101]). In addition, many other EU countries such as the Czech Republic, Estonia, Finland, Spain and Sweden have made broadband investments utilising the RRF.

In New Zealand, parts of the *Rural Capacity Upgrades programme* and the *Marae Digital Connectivity program (MDC)* stem from the *COVID Recovery Fund*. In phase one of the *Rural Capacity Upgrades programme*, 70 mobile broadband towers in rural areas have been upgraded to ease network congestion at the start of the first public health lockdown. NZD 15 million (USD 10.6 million) was provided for rural towers, and NZD 50 million (USD 35.4 million) in general capacity upgrades such as towers, fibre and

additional connectivity for Marae. (Crown Infrastructure Partners Limited, 2022_[102]).¹⁹ *Project Gigabit*, launched by the United Kingdom government in 2021, aims at funding high-quality broadband connections. GBP 5 billion is dedicated (USD 6.41 billion) to subsidise the roll-out of high-quality broadband to the “hardest to reach” premises in the country, mostly in rural areas. The project aims to ensure 85% of the country is covered by high-quality broadband by 2025. According to a report, as of June 2023, 76% of premises are now able to access a high-quality capable connection (“gigabit-capable”) and over 50% of premises are covered by a full-fibre network, up from just 22% in April 2021 (GOV.UK, 2023_[103]).²⁰

Some countries are supplementing existing programmes with additional funding in response to the COVID-19 health crisis. Canada established the *Universal Broadband Fund* (UBF) in 2020. Although it is not designed in direct response to the COVID-19 health crisis, total funding under the UBF was increased prior to its launch, in large part because of the COVID-19 health crisis. Specifically, the UBF was originally announced in the 2019 budget as a CAD 1 billion (USD 0.75 billion) programme. Additional funding was provided, and the UBF was launched as a CAD 1.75 billion (USD 1.3 billion) programme in 2020. The UBF has since received additional top-ups and is now a CAD 3.225 billion (USD 2.47 billion) programme (Government of Canada, 2022_[104]). In Norway, *Nkom fund* has been in place for many years. The total state aid in the period 2014-2023 is close to NOK 2 400 million (USD 279 million), and NOK 100 million (USD 11.6 million) was added in response to COVID in 2021 (Nkom, 2023_[105]).²¹²²

Public funding to bridge connectivity divides

Public financial support may be used to boost broadband deployment in underserved regions like sparsely populated or remote areas and in places where people lack adequate access due to social and economic factors. In OECD countries, public support frequently concentrates on closing gaps in rural and remote areas, with COVID-19 recovery programmes also often prioritising this aspect. Countries further established national strategies and broadband plans to advance digital development and employ public funding initiatives to meet the goals set out in these plans.

The *Better Connectivity Plan for Regional and Rural Australia* aims at improving mobile and broadband connectivity and resilience in rural and regional Australia, with ASD 656 million (USD 455 million) in funding in the 2022-23 October Federal Budget over five years (DITRDCA, 2023_[106]).²³ In Chile, the *Telecommunications Development Fund* (“Fondo de Desarrollo de las Telecomunicaciones”, *FDT*) aims to promote coverage of communication services in rural and low-income urban areas, with low or non-existent deployment of such services due to economic infeasibility (Subsecretaría de Telecomunicaciones, 2023_[107]). The Finnish Government has been allocating state aid through a broadband programme since 2011. The budget of the programme is EUR 32 million (USD 33.7 million) for 2022-2023. The target of the programme is to achieve high-quality connectivity for at least 6 400 dwellings before the second half of 2024 and 16 000 dwellings in commercially challenging areas before the second half of 2026 (TRAFICOM, 2022_[108]). The German federal government has provided around EUR 17 billion (USD 17.9 billion) to fund broadband deployment since 2015. The *Gigabit funding 2.0* (“Gigabitförderung 2.0”) project started in 2023 and allocates additional EUR 3 billion (USD 3.1 billion) annually to finance 50 to 70 percent of the high-quality broadband expansion in areas without prospects for private sector investments (BMDV, 2023_[109]).²⁴

As all public funding programs, initiatives with a geographic focus need to avoid crowding out private investment. Many OECD countries take steps to collect and map regional data related to funding to accurately identify areas where government assistance may be genuinely required, while maintaining competition and not hindering private investments. For instance, the *Guidelines on State aid for broadband network* outline how the European Commission will evaluate State aid measures for broadband networks in the European Union. It emphasizes the importance of detailed coverage mapping, thorough analysis, and public consultation by member states of the European Union to determine the necessity of intervention in specific regions when providing financial support for broadband deployment (EUR-Lex, 2022_[110]).

Funding may also focus on social and economic conditions. For example, the *First Nation Infrastructure Fund* (FNIF) in Canada helps indigenous communities in Canada to upgrade and increase public infrastructure including broadband to improve the quality of life and the environment for Indigenous peoples (Government of Canada, 2022^[111]). In Mexico, the government *Social Coverage 2022-2023 programme* (“Cobertura Social 2022-2023”) considers vulnerable locations and groups, including low income and remote areas, and low income, indigenous, and afromexican groups (DOF, 2023^[112]). The *Tribal Broadband Connectivity Program* (TBCP) in the United States is a USD 3 billion programme, resulting from the Bipartisan Infrastructure Law and the Consolidated Appropriations Act, to support Tribal governments bringing high-speed Internet to Tribal lands, including telehealth, distance learning, affordability, and digital inclusion initiatives (NTIA, 2023^[113]).

Public funding to promote environmental sustainability

Ensuring a sustainable future is at the heart of policy agendas across OECD countries. Economic recovery packages placed emphasis on structural reforms to reduce carbon emissions by acknowledging that digital and “green” policies are intertwined, and together may help achieve this objective. For example, the Korean Government launched the “New Deal” in July 2020, which places digital policies, together with sustainability, as the two key pillars of their “National Strategy for a Great Transformation”, where connectivity plays a key role (Ministry of Economy and Finance of Korea, 2020^[114]). The *Smart Readiness programme* in Greece subsidises the implementation of projects related to the installation of infrastructure that will facilitate a “smart” transformation, as well as its interconnection with utility networks such as electricity and natural gas, through new smart meters. For this purpose, the Program provides vouchers with the aim to cover part of the costs (Ελλάδα 2.0, 2023^[115]).

Approaches to public funding of broadband deployment

Public financial support often takes the form of subsidies and public procurement. There are many different forms of subsidies including direct government expenditures, tax incentives, equity infusions, soft loans, government provision of goods and services and procurement on favourable terms, and price supports (IMF et al., 2022^[98]). Public procurement refers to the purchase by governments and state-owned enterprises of goods, services and works (OECD, 2023^[116]). In the realm of broadband infrastructure, common ways include grants and public tenders. These transfers of funds primarily occur from public institutions to business operators. Additionally, transfers between public institutions are prevalent. Funding in the communication sector is often administered by relevant authorities. Separate entities may also be established for fund management, including for universal service funds. Occasionally, public-private partnerships and blended finance arrangements involve both public institutions and the private sector in funding initiatives.

Direct subsidies may be directed to businesses such as communication operators that build out broadband infrastructure. The public sector typically offers subsidies to broadband operators who meet specified criteria, covering part or all their development costs. This support can be in the form of grants or tenders, where operators bid for contracts to undertake broadband development. A less common approach may consist in equity investments.

Another approach to public funding may involve the flow of public funds from one public institution to another. The specifics of this process can vary based on the administrative structures of different countries and regions. As a typical illustration, the national government may allocate subsidies from its treasury to local governments, or local governments may apply for these subsidies. Subsequently, the recipient local government enters into a contract with communication operators. For example, in the *Broadband Equity, Access, and Deployment (BEAD) Program* in the United States, USD 42.5 billion of subsidies from the national budget will be distributed to each state (Internet for All, 2023^[117]) which, in turn, allocate the funds to communication operators. In the Norwegian *Nkom fund*, the *Ministry of Local Government and District*

Affairs (KDD) is responsible for the scheme with public support from the state budget for the development of broadband. The funds are distributed to the county municipalities according to a distribution list prepared by KDD in consultation with Nkom (Nkom, 2023^[105]). In addition, there are cases where local governments receive grants to develop their own broadband infrastructure. For example, in Japan, the *Project to Promote Advanced Wireless Environment* provides subsidies to develop base stations and backhaul infrastructure for mobile services in underserved areas. Not only mobile operators but also local governments that install base station facilities and backhaul infrastructure themselves may apply for subsidies (MIC, 2023^[118]).

In some cases, governments may establish or select entities to manage and operate funds. Establishing or designating a separate entity may have merits in managing and providing funds over the medium to long term. Several OECD countries established universal service funds (USFs) to provide broadband services nationwide. Funding sources for USFs come in various patterns, such as funds collected from operators. The constitution of USFs makes it possible to aggregate and manage different sources of funding simply and comprehensively, to increase the transparency of funds management and facilitate use of efficient distribution of public funds (OECD/IDB, 2016^[119]). In cases where funding is offered by multiple public entities and levels of government, it is important to ensure strong coordination between these public entities. In addition, when operating the USF, as with other public aid, it is necessary to clarify the goals to be achieved regarding network development and be careful not to unnecessarily affect the competitive environment.

In Germany, the *Mobile Funding Programme* (“Mobilfunkförderung”) amounts to a total budget of EUR 1.1 billion (USD 1.3 billion). It aims at ensuring 5G-capable funded mobile sites with at least 4G-coverage in white spots (BMDV, 2021^[120]).²⁵ This project is operated by *Mobile Communication Infrastructure Company* (“Mobilfunkinfrastrukturgesellschaft”), MIG. MIG was founded on behalf of the *Federal Ministry of Transport* (BMVI) in 2021 as a subsidiary of *Toll Collect GmbH* (MIG, 2021^[121]). New Zealand’s broadband public funding programmes are administered by *Crown Infrastructure Partners Limited* (CIP). CIP’s forerunner was created under the Public Finance Act of 1989 to oversee the New Zealand government’s investment in high-quality broadband infrastructure (New Zealand Government, 2022^[122]). Lithuania chose a broadband financing model, where funding from the European Union and state budgets is allocated to *Broadband Internet* (“Plačiajuostis Internetas”), a non-profit organisation established in 2005, which installs broadband in rural and remote areas and provides wholesale broadband services to communication operators at equal conditions and prices (Plačiajuostis internetas, 2023^[123]).

Public and private sector may complement each other through public-private partnerships (PPPs) to structure public funded broadband access extension plans or projects that take advantage of synergies that benefit both private and public interests. In addition, there are cases where public financial support is provided in collaboration with private entities²⁶ (Box 7).

Box 7. Public funding in collaboration with private entities in the Republic of Slovenia and Japan

Since 2008, the Republic of Slovenia has been co-financing the construction of broadband networks in white spots through public funds in areas where operators have no market interest. Co-financing has been provided by consortiums which consist, among others, of municipalities, communication operators, and ministries based on a PPP, along with private financing (The Ministry of Education, Science, and Sport, 2016^[124]). In Greece, the project “Ultra-Fast Broadband Infrastructure” (UFBB) represents a PPP which aims at ensuring high-quality broadband access in areas that have not been reached by private investments. The project has an initial budget of EUR 870 million (USD 916 million) including VAT. Of this, EUR 300 million (USD 316 million) are co-financed by public funds, covered by

the *European Structural and Investment Funds*, and private funds (Ministry of Digital Governance, 2023_[125]).²⁷

In Japan, the *Fund Corporation for the Overseas Development of Japan's ICT and Postal Services* (JICT), a public-private joint fund, was established in 2015 to invest in communication infrastructure outside of Japan. As for demand risks due to sudden changes in national systems and policies, JICT aims to bear part of the risk through the supply of long-term funding to communication businesses. JICT has received JPY 87 billion (USD 661 million) from the Japanese government and JPY 2.4 billion (USD 18.2 million) from the private sector. As of October 2023, planned investments in 2023 are of JPY 24.4 billion (USD 185.5 million) (MIC, 2023_[126]).²⁸

Public utilities such as electricity, gas and water, also play a role in public funding in several OECD countries (see Box 8). In addition, municipal and community-led networks have been developed in rural areas in OECD countries, often in response to perceived underinvestment in the community by the incumbent network operators. Though ownership of the wholesale part of the network infrastructure may remain with the municipality, retail market competition can be maintained for consumers by making the networks open accessible to any service provider (OECD, 2021_[127]).

Municipal networks, which are high-speed networks that have been fully or partially facilitated, built, operated or financed by local governments, public bodies, utilities, organisations, or co-operatives that have some type of public involvement (OECD, 2015_[128]), are used in several OECD countries to promote fibre deployment in cities, smaller towns and surrounding regions. Community networks are often bottom-up approaches that build on local knowledge and initiatives (i.e. grass-roots movements), and can play a complementary role with respect to national service providers to bridge connectivity divides (APC, 2020_[129]; OECD, 2021_[127]).

Box 8. Fibre deployment by the electricity utilities in Denmark

In 2004, the Danish electricity sector was subject to a major reorganisation. In return for divesting the backbone transmission system to a state-owned transmission system operator (TSO) – the electricity utilities were allowed to invest their equity capital outside the sector. Soon thereafter, a majority of the consumer-owned co-operative electricity companies in Denmark began investing in deployment of fibre to the home.

When electricity companies began investing in fibre deployment in Denmark, there were in total under 4 000 FTTH subscriptions nationwide (The Danish Agency for Data Supply and Infrastructure, 2022_[130]). As of 2023, the footprint is above 1 million subscriptions out of a total fixed broadband market of approximately 2.6 million subscriptions. The deployment centred locally or regionally within the original electricity distribution areas. As of May 2023, investments in fibre by Norlys, a Danish electricity company, was estimated at DKK 12 Billion (USD 1.7 billion).²⁹

Publicly funded broadband technologies

When public authorities provide funding for broadband development, it is desirable to adopt technological neutrality – not specifying the communication technology to be used – and rather to select and evaluate it based on objectively defined criteria. This may maximise the envisioned outcome, for example with respect to the cost involved. The revised *Guidelines on State Aid for Broadband Networks* in the European Union, for instance, set out some requirements based on the principle of technological neutrality (EUR-Lex, 2022_[110]). Based on this, for example, the Republic of Slovenia set out conditions including transparent

and non-discriminatory competitive procedures for the selection of network contractors while respecting the principle of technology neutrality (The Ministry of Education, Science, and Sport, 2016^[124]). Some countries however choose to prioritise funding to specific network technologies. For example, some countries prioritise funding for end-to-end fibre deployments because of its scalability and catalysing effect on other communication technologies.

Within the communication technologies subject to public funding for broadband development, many projects aim at promoting the deployment of fixed high-quality access networks and 5G mobile access networks. In addition, investment in backhaul, which is connected to fibre or 5G, is common. Less prominent examples include investments in satellite or fixed wireless access.

The European Recovery and Resilience Facility (RRF) may provide a case in point for technology trends in public funding. Here, four main areas of investments in connectivity can be identified: investments in backbone/backhaul networks, investments in fixed high-quality access networks, investments in 5G mobile access networks and other investments. Investments in backbone/backhaul networks are worth EUR 8.7 billion (USD 9.2 billion) in total and concern in particular investments to provide broadband coverage in market failure areas and to connect islands with fibre submarine cables. Investments in fixed high-quality access networks are worth EUR 3.2 billion (USD 3.4 billion) and concern measures aimed for instance at deploying fibre access networks until and/or within the premises. Out of these, EUR 2.3 billion (USD 2.4 billion) concern deployments of fixed very high-capacity access networks serving individual households and businesses, while EUR 0.9 billion (USD 0.95 billion) are linked to the deployment of fixed high-quality access networks serving multi-dwelling premises. Investments in mobile high-quality access networks in approved RRFs are worth EUR 3.5 billion (USD 3.7 billion) and concern in particular measures aimed at supporting the deployment of 5G networks in market failure areas and alongside 5G corridors. Finally, measures aimed at providing fibre backhauling for mobile base stations account for the remaining EUR 1.1 billion (USD 1.2 billion) (European Commission, 2023^[131]).³⁰

Canada provides an example of public funding for satellites. The Government of Canada entered into an agreement with *Telesat* to secure high-speed Internet capacity over Canada through the company's LEO satellite constellation. *Telesat*'s constellation will utilise next-generation technology to significantly improve connectivity in rural and remote Canada. Under the agreement, the government committed up to CAD 600 million (USD 478 million) to secure capacity on the constellation. This capacity will be made available to ISPs at a reduced rate to provide high-quality, reliable broadband access to rural and remote communities in Canada (Government of Canada, 2021^[132]).³¹

Conclusion

From 2008 to 2022, communication operators demonstrated stable profit margins. However, their return on invested capital (ROIC) gradually decreased over time. This decline as well as the convergence of ROICs between incumbents and challengers may result from differences in capital costs and market conditions, management decisions, as well as levels of competition. The rise of debt on the balance sheets of operators can, among other factors, be attributed to the availability of low-cost capital and an increased willingness to take on debt during times of low interest rates. Recent increases in interest rates may place additional pressure on the cost of capital.

Further growth of investments depends on revenue development, as without sufficient revenues, investments in absolute terms may not witness significant expansion. The decreasing return on invested capital further compounds the challenge of garnering support for additional investments, especially regarding management goal of maintaining shareholder value through dividend yield. Nevertheless, the requirements differ among communication companies and financial investors, as some infrastructure investors are accustomed to foregoing dividends for a period while expecting value upon exit, while others demand a continuous flow of dividends to retain their shares.

Communication operators increasingly sold tower assets to specialised tower companies to monetise on their assets to release capital for investments, distribute dividends or to reduce their debt levels. Nearly all MNOs are seeking to benefit from their past investment in passive infrastructure to raise capital or income streams. Some chose to sell full or majority stakes in their towers and become long-term tenants, some sold minority portions through taking on partners or stock market floats of spun-off units, and others by simply creating a separate unit to sell space to competitors.

Another growing part of investments in broadband infrastructure comes from big publicly listed technology companies. These have been building large data centres around the world as well as backbone and access networks, particularly submarine cables. Investments by tech companies primarily aim at efficient and stable traffic distribution. In the process of achieving these goals, tech companies are working together with communication operators in various areas within the communication infrastructure ecosystem.

Financial asset managers, including private equity firms, hedge funds, and pension funds, are playing an increasingly significant role in funding communication infrastructure and services. The shift in investment patterns is exemplified by the substantial growth of capital raised by private equity funds focused on communication infrastructure. The expansionary policies of central banks, combined with low interest rates and a global surplus of savings, have incentivised asset managers to seek long-term investments in communication infrastructure. While ongoing projects are usually hedged, increasing interest rates may put large parts of greenfield investment at risk.

While recovery from the COVID-19 health crisis may be categorised as a short-term goal, OECD countries also have invested various public funds for the deployment of broadband to bridge connectivity divides with a long-term perspective to address geographic and socioeconomic differences. Moreover, in recent years, promoting the environmental sustainability of communications networks has become increasingly important. Public funding of broadband infrastructure should have a well-defined purpose, avoid distorting

competition, utilise diverse funding methods, prioritise transparency in fund management, consider regional needs when selecting technologies, maintain technology neutrality, and rely on objective criteria for cost-effective results.

The role of public policy and regulation in enabling inclusive access to connectivity is evolving constantly. While public funds are one way to increase the deployment of broadband networks, the public sector has a crucial role in shaping regulatory frameworks that are conducive to investments in the communication sector and optimise the domestic environment to attract investments, while maintaining other goals such as a competitive landscape, continued innovation in the market and other legislative frameworks around an open Internet and network neutrality.

Experience in OECD countries has shown that operators base their investment choices on the legal and regulatory framework and the market structures in place. Among others, such frameworks work best if structures and agencies are created to make decisions in an independent, impartial and objective way. Independent regulators, for example, ensure that regulation is developed in an objective way and provide the basis for investment certainty. A sound regulatory environment furthermore fosters competition, which has been one of the most effective levers to achieve high-quality, affordable and accessible connectivity as competition drives investments as well as innovation. Another important lever to promote investments in broadband deployment is through facilitating infrastructure deployment, rendering it less costly and faster for the private sector to deploy networks through efficient, transparent and predictable policy frameworks. Simplifying licencing procedures and permits for network constructions, as well as streamlining access to rights of way bring costs significantly down and provides investment-friendly environments³².

Numerous players and stakeholders are involved in financing the broadband networks of the future. All of these players need to be considered when assessing whether investment levels are sufficient to address gaps in coverage and quality. This report intended to provide an overview of the different investment efforts by those actors, using available data. Meeting the needs for high-quality connectivity networks further requires collaboration among all these players and stakeholders. An open dialogue among all actors – including industry, the financial sector, non-profit organisations, governments, multilateral bodies, or civil society – is indispensable to finance the broadband networks of the future.

Annex 1.A. Bloomberg Dataset

- Data period: 2008-2022
- Criteria: Companies listed at any stock market in the world, providing communication services or facilitating the provision of communication services
- Number of companies: 195
- Filter for companies to be included: Minimum market capitalisation USD 1.0 billion
- Number of currencies: 50 (exchange rate USD, calculated per year based on one data point per month)
- Number of data points: 17424 (2941 lines in Excel)
- Number of countries: 59
- Total number of employees in the 195 companies: 5.6 million
- Total market capitalisation of the 195 companies: USD 3.1 trillion (May 2023)

Bloomberg Industry Classification Standard (BICS), consists of five categories:

- Telecommunication carrier (telecommunications, wireless telecommunication, wireline telecommunication, named “communication carrier” in this report)
- Infrastructure construction (communication & transmission construction)
- Cable & Satellite
- Consumer electronics
- Publishing & Broadcasting

The data set includes operators from the following regions:

- Europe
- United States and Canada
- Latin America
- Asia Oceania
- Middle East Africa

Annex Table 1.A.1. Number of companies according to classification and categorisation

	Challenger	Incumbent	Total
Telecommunication carrier	88	51	139
Cable & Satellite	36	1	37
Infrastructure construction	11	0	11
Consumer electronics	3	0	3
Publishing & Broadcasting	5	0	5

Measures used by Bloomberg are defined as follow:

- capex_to_sales, Capital Expenditures to sales,
 - measure of the percentage of capital expenditures to sales. Capex are funds used by a company to acquire, upgrade, and maintain physical assets such as property, industrial buildings, or equipment.
- roic, Return on invested capital (ROIC)

- ROIC indicates how effectively a company uses the sources of capital (equity and debt) invested in its operations. Average Invested Capital is the average of the beginning and ending balance of Total Invested Capital (RX215, TOTAL_INVESTED_CAPITAL). The total invested capital measures the total amount of money that was endowed into a company by the shareholders, bondholders and all other interested parties.
- Return is measured as Net Operating Profit after Tax (NOPAT).
- `netdebt_to_EBITDA`, Net debt/EBITDA,
 - Net debt shows a business's overall financial situation by subtracting the total value of its cash, cash equivalents and other liquid assets, a process called netting. All the information necessary to determine a company's net debt can be found on its balance sheet. The formula to calculate net debt is as follows: $\text{Net Debt} = (\text{Short-Term Debt} + \text{Long-Term Debt}) - \text{Cash and Cash Equivalents}$.

Calculations for the different parameters are based on revenue (USD) weighted average. The movement on the currency markets has led to a stronger USD in relation to a number of the currencies in this data set. The calculations are based on straight exchange rates with annual rates calculated as an average of one data point per month and no adjustments have been done for PPP. However, a number of currencies in the data set are linked to USD which mean that the values reflect the underlying business. Moreover, nominal values are used, i.e. no deflating took place.

Annex 1.B. Selected transactions involving tower companies since 2019

Annex Table 1.B.1. Selected transactions involving tower companies since 2019

Countries	Companies and Transactions
Australia	In 2021 Telstra sold a 49% share in its newly created tower company Amplitel, to a consortium led by the Australian Government's Future Fund, which is a sovereign wealth fund, for AUD 2.8 billion (USD 2.1 billion) (CRN, 2021 ^[133]). Meanwhile, Singtel, owner of the Australian MNO Optus, sold a controlling stake in its tower entity to AustralianSuper for USD 2.63 billion (Bain & Company, 2023 ^[88]). In May 2022, TPG, which had previously merged with Vodafone Australia, sold 1,237 Tower Assets sites including 428 towers and 809 rooftop sites for AUD 950 million (USD 658.8 million) to Canadian pension fund OMERS with a 20-year lease back arrangement (Financial Review, 2022 ^[134] ; Macquarie, 2023 ^[135]). The other major transaction, in April 2022, was the sale of Axicom for AUD 3.58 billion (USD 2.48 billion), Australia's largest independent mobile towers owner, operating approximately 2,000 telecommunication sites (Macquarie, 2022 ^[136]).
Austria and Germany	In July 2022, Deutsche Telekom sold a 51% stake in its tower assets in Germany and Austria at a valuation of 27x EBITDA to a consortium made up of Brookfield and Digital Bridge (Livewire, 2022 ^[137]). The investment by the two companies was USD 10.7 billion (Bain & Company, 2023 ^[88]).
Argentina, Brazil, Chile, Germany, Peru, Spain	In January 2021 Telefónica announced the sale of 100% of its subsidiary Telxius Telecom, S.A. (a company of the Telefónica Group minority-owned, directly or indirectly, by KKR and Pontegadea), to American Tower Corporation ("ATC") (Telefónica, 2021 ^[138]). Telxius operates towers in Europe (Spain and Germany) and in Latin America (Brazil, Peru, Chile and Argentina). The company said the sale was valued at EUR 7.7 billion (USD 9.1 billion), payable in cash. The capital gain attributable to Telefónica is estimated to amount to approximately EUR 3.5 billion (USD 4.1 billion). Once the transaction is complete, the Telefónica Group's net financial debt will be reduced by approximately EUR 4.6 billion (5.4 billion).
Belgium	In June 2022, Digital Bridge acquired the mobile telecommunications tower business ("TowerCo") of Telenet Group Holding NV (Euronext Brussels: TNET, "Telenet") for AUD 791 million (USD 487 million) (including transaction costs).
Brazil	In July 2023, Oi Brasil, completed the sale of selected tower infrastructure to <i>Empreendimentos e Participacoes</i> , an affiliate of comms infrastructure group Highline. The deal, originally announced in August 2022, added 8,000 towers to Highline 3,800 tower sites across Brazil. It is reported that the sale could earn Oi Brasil USD 350 million depending on usage (Developing Telecoms, 2023 ^[139]).
France and Spain	In 2021, Orange set up Totem, as a separate business to manage some 26,882 towers in France and Spain. It retains 100% ownership setting the company apart from piers such as BT, Deutsche Telekom, Telecom Italia, Telefónica and Vodafone which has sold towers in recent years (Light Reading, 2022 ^[140]).
Greece	EETT has examined, under the provisions of the Greek competition law (Law 3959/2011- Law 4886/22), the notification of the joint venture between the two Greek mobile operators, namely Vodafone Hellas and NOVA SA, in order to create "Vantage Towers" Greece. On this respect, EETT with its decision number 967/1/2020 gave a clearance to the examined merger. After the transaction, the Greek TowerCo became member of Vantage Towers Group, a Germany-based leading European Tower Company, being fully controlled by VODAFONE GROUP Plc., which initially held the 82% of the company's shares, with the rest free float being the result of the completion of the IPO during March 2021. Within 2023, Vodafone Group entered into a strategic co-control partnership with a consortium of long-term infrastructure investors led by Global Infrastructure Partners ("GIP") and KKR (together the "Consortium") for Vodafone's 81.7% stake in Vantage Towers Group. As of December 2023, Vantage Towers Greece with more than 5.280 towers and more than 20 customers hosted on its infrastructure, is ranked as the third biggest market of Vantage Towers Group. Furthermore, Vantage Towers Greece is a TowerCo in Greece, with a market share close to 50%. According to the published financial results of March 2022 it has presented a revenue of ~140 million and positive revenue trend is expected to be continued.
India	In 2020, GIC — the sovereign wealth fund of Singapore — and Brookfield Infrastructure Partners, acquired a 100 per cent stake in a telecom tower company from a subsidiary of Reliance Industries Ltd for USD 3.4 billion (The Telegraph, 2020 ^[141]). This involved 135,000 towers, built for Reliance Jio Infocomm Ltd's (Jio).
Indonesia and the Philippines	In May 2022, a consortium led by Macquarie Asset Management, including the Public Sector Pension Investment Board (PSP Investments), acquired a stake in Bersama Digital Infrastructure for USD 610 million (Dgtl Infra, 2022 ^[142]). By October 2022, Macquarie had a 73.3% stake in Tower Bersama, a leading independent telecommunication towers business in Indonesia with over 20,500 towers and 39,000 tenancies (Macquarie, 2022 ^[143]). Macquarie also led a consortium to buy 1,350 cellular towers from Globe Telecom—the Philippine operator jointly owned by Ayala Corp. and Singapore Telecommunications USD 340 million (Forbes, 2022 ^[144]). The transactions in both countries followed the lift of foreign ownership restrictions on telecommunication towers.

Italy	In August 2022, Telecom Italia (TIM) said all conditions had been met to allow it to complete the sale of an indirect stake in Italian tower company INWIT (TeleGeography, 2021 ^[145]). Under an agreement signed on 14 th April a consortium led by investment firm Ardian is to acquire a 41% interest in Daphne 3, a holding company which owns 30.2% of INWIT, for approximately EUR 1.3 billion (USD1.33 billion), in addition to the repayment of a loan of approximately EUR 200 million (USD 210 million). The deal reduced TIM's stake in Daphne 3 to 10%, while the Ardian group increased its holding to 90%. It also meant the termination of a shareholders' agreement between INWIT investors TIM, Daphne 3, Vodafone Europe and Central Tower Holding Company.
Japan	In May 2022, NTT Docomo agreed to sell 6,002 towers to Jtower for JPY106.2 billion (USD 870 million), which the operator then leased back, under an expansion of the two companies network sharing efforts (Mobile World Live, 2022 ^[146]). In November 2021, the two companies had announced a capital and business alliance, with the operator acquiring part of the Jtower shares held by its parent company and become a shareholder with 2.5 per cent voting rights. In July 2021 Docomo's parent NTT in July agreed to sell 71 towers to Jtower. In October 2021, new Japanese operator Rakuten Mobile also formed a capital tie-up with Jtower and acquired a stake in the tower company (RCR Wireless News, 2021 ^[147]).
Korea	Wiable Corp (Yahoo, 2023 ^[148]). Operates in the telecommunications industry in Korea. The company constructs base station infrastructure for the use in various wireless communication service operations, mobile communications, national disaster safety network operations, and other wireless communication services, as well as in subways, road tunnels, national highways, national roads, national parks, mountains, and islands. It also offers railway integrated wireless communication network services using high-speed wireless communication technology; terrestrial broadcasting services; Wi-Fi enabled communication network services; and traffic information wireless communication infrastructure services. In addition, the company provides wireless communication systems inspection and maintenance services; and base station communication equipment and vehicle terminal equipment. The company was formerly known as KRTnet Co., Ltd. And changed its name to Wiable Corp. in March 2021.
Mexico, Argentina, Brazil, Chile, Costa Rica and others	In 2022, America Movil (AM) completed the spin off of its tower unit Sitios Latinoamerica (SITES Latam). The towerco has an initial inventory of 30,700 towers on an aggregate basis, 11,600 of which are in Brazil. SITES Latam also operates towers in Argentina, Chile, Costa Rica, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Paraguay, Peru, Puerto Rico and Uruguay (TeleGeography, 2022 ^[149]).
Mexico	In August 2023, Macquarie Asset Management Mexico took control of the administration of 18% of Altán Redes. The Mexican Government became the majority shareholder in 2022. In the same year, América Móvil's Telmex sold 9,000 towers to TeleSites, the tower company created for the Mexican market, for 7bn pesos (BNamericas, 2022 ^[150]).
New Zealand	Connexa was formed in July 2022, with the acquisition of a 70% stake in Spark New Zealand's ("Spark") passive mobile tower infrastructure assets by Ontario Teachers' Pension Plan, with Spark retaining 30%. That transaction was completed in October 2022. In 2023, Connexa acquired the tower assets of Two Degrees Mobile ("2degrees") and Spart's share in Connexa fell to 17% (Financial Review, 2022 ^[151] ; Two Degrees Mobile, 2023 ^[152]). In addition, during 2022, Vodafone NZ, sold its towers to a group of investment funds including the United Kingdom based InfraRed Capital Partners, part of the Sun Life insurance group, and Northleaf Capital Partners of Canada, will each take 40 percent, with Vodafone half owner Infratil taking 20 percent (RNZ, 2022 ^[153]).
Poland, France and Italy	In June 2023, Iliad S.A. announces the sale of its residual 30% stake in On Tower Poland ("OTP"), the company that manages the Group's passive mobile telecommunications infrastructure in Poland, to the Cellnex Group for PLN 2.3 billion (USD 515 million) (before tax) (Iliad, 2023 ^[154]). The sale follows the completion of the transaction consisting in the sale of 60% of OTP to the Cellnex Group on 1 st April 2021, and a further sale (of 10% of OTP) on 28 th February 2022. Iliad had earlier sold its tower assets in France and Italy to Cellnex for EUR 2 billion euros. In June 2023, sold its tower assets in Poland to Emitel, a subsidiary of Cordiant Digital Infrastructure (DCD, 2023 ^[155]). Financial terms were not disclosed. The deal sees the transfer of 65 towers, which increases Emitel's total site portfolio to 667, of which over 635 will host telecom equipment.
Slovenia, Bulgaria, and Croatia	In April 2023, Saudi Telecom Co.'s subsidiary, Telecommunications Towers Co., or TAWAL, acquired tower assets for USD 1.3 billion from the Netherlands-based United Group, extending its reach into the European market (Arab News, 2023 ^[156]). This increased TAWAL's tower portfolio, to over 21,000 sites across five countries
Sweden, Norway and Finland	On 27 th January 2022, Telia announced the sale of 49% of its tower business in Sweden to Brookfield and Alecta, a Swedish pension fund, at a price corresponding to an enterprise value (EV) for 100 percent of SEK 11,224 million (USD 1,109 million) on a cash and debt free basis. Telia said the valuation of the Swedish tower business equals 28.2x normalized EBITDA 2021 (Telia Company, 2022 ^[157]). The transaction of the minority stake in the Swedish tower business, and the previous completion of the sale of 49% of Telia's Norwegian and Finnish tower business to Brookfield and Alecta, as announced on 29 th December 2021, the tower assets are placed in Telia Towers AB which is 51 percent owned by Telia with the remaining 49% owned by Brookfield and Alecta.
United Kingdom and nine other European countries	In November 2022, Vodafone announced it would enter into a co-control partnership with Global Infrastructure Partner (GIP) and KKR for Vantage Towers and deconsolidate their tower unit, buying out minority investors (Vodafone, 2022 ^[158]). Vantage operates 82,000 towers across the Czech Republic, Germany, Greece, Hungary, Ireland, Italy, Portugal, Romania, Spain, United Kingdom. At the time of the announcement Vodafone owned 81.7% of Vantage Towers and the new joint venture was named Oak Holdings. The deal, which values the towers unit at USD 18 billion was finalized in early 2023. As of mid-2023 Oak Holdings owned 89% of Vantage Towers with Vodafone's stake being 60% and the two private equity consortium 40% (DCD, 2023 ^[159]). In total Vodafone reaped EUR 5.4 billion (USD 6 billion) from the sale.

	<p>Towards the end of 2022, Cellnex completed its acquisition of CK Hutchison's towers business in the United Kingdom (DCD, 2023_[160]). It was part of a transaction originally agreed between Cellnex and CK Hutchison back in 2020 to see the former acquire the latter's telecommunication sites in the six European countries for a combined total of USD 10.9 billion.</p>
United States	<p>In 2020, American Tower Corporation announced an agreement to acquire InSite Wireless Group, LLC ("InSite"), which then owned, operated and managed approximately 3,000 communications sites, primarily in the United States and Canada (American Tower, 2020_[161]). This included more than 1,400 owned towers in the United States, over 200 owned towers in Canada and approximately 70 distributed antenna system ("DAS") networks in the United States. In addition, InSite controlled more than 600 land parcels under communications sites as well as approximately 400 rooftop sites. The total consideration for the transaction, including cash acquired and the Company's assumption and/or repayment of InSite debt at closing, is approximately USD 3.5 billion.</p> <p>In 2021, American Tower acquired CoreSite Realty Corporation for approximately USD 10.1 billion (CoreSite, 2021_[162]). The transaction aims to create an interconnected communications real estate platform optimally positioned to benefit from the convergence of wireline and wireless networks amid accelerating global 5G deployments. In 2020,</p> <p>In 2022, Global investment firm Carlyle announced that funds managed by its Global Infrastructure platform have committed up to USD 1 billion to partner with Tillman Global Holdings to accelerate its investments in Tillman Infrastructure, a leading privately held cell tower platform in the United States (Carlyle, 2022_[163]).</p> <p>In March 2023, Radius Global Infrastructure entered into a definitive agreement under which EQT Active Core Infrastructure ("EQT") and the Public Sector Pension Investment Board ("PSP"), through certain of their controlled affiliates, will acquire the Company (Radius Global Infrastructure, 2023_[164]). Radius Global Infrastructure, Inc., through its various subsidiaries, is a multinational owner and acquiror of triple net rental streams and real properties leased to wireless operators, wired operators, wireless tower companies, and other digital infrastructure operators as part of their infrastructure required to deliver a wide range of services.</p>

Note: Exchange rates from OECD.stat have been used for the respective years of transaction.

Annex 1.C. Submarine cable holdings of big technology companies since 2010

Annex Table 1.C.1. List of tech companies' submarine cable holdings

Tech company ³³	Role	Cable name	Other owners	Year	Length	Main route
Google	Partial ownership	Unity/EAC-Pacific	Bharti Airtel, KDDI, Singtel, TIME 51otcom, Telstra	2010	9,620 km	East Asia – North America
Google	Partial ownership	Southeast Asia-Japan Cable (SJC)	China Mobile, China Telecom, Chunghwa Telecom, Globe Telecom, KDDI, National Telecom, Singtel, Telkom Indonesia, Unified National Networks (UNN)	2013	8,900 km	Southeast Asia – East Asia
Microsoft	Major capacity buyer	EXA Express	EXA Infrastructure	2015	4,600 km	North America – Europe
Google	Partial ownership	FASTER	China Mobile, China Telecom, KDDI, Singtel, TIME dotCom	2016	11,629 km	East Asia – North America
Meta, Microsoft	major capacity buyer	AEC-1	Aqua Comms	2016	5,521 km	North America – Europe
Meta	Partial ownership	Asia Pacific Gateway (APG)	China Mobile, China Telecom, China Unicom, Chunghwa Telecom, KT, LG Uplus, NTT, National Telecom, Starhub, TIME 51otcom, VNPT International, Viettel Corporation	2016	10,400 km	Southeast Asia – East Asia
Google	Partial ownership	Monet	Algar Telecom, Angola Cables, Antel Uruguay	2017	10,556 km	North America – South America
Amazon	Major capacity buyer	Hawaiki	Hawaiki Submarine Cable LP	2018	14,000 km	Oceania – North America
Amazon, Meta, Microsoft	Major capacity buyer (amazon) partial ownership (Meta, Microsoft)	MAREA	Telxius	2018	6,605 km	North America – Europe
Google	Sole owner	Junior		2018	390 km	South America
Google	Partial ownership	Tannat	Antel Uruguay	2018	2,000 km	South America
Microsoft	Partial ownership	New Cross Pacific (NCP) Cable System	China Mobile, China Telecom, China Unicom, Chunghwa Telecom, KT, Softbank Corp	2018	13,618 km	East Asia – North America
Google	Partial ownership	INDIGO-Central	Australia's Academic and Research Network (AARNET), Indosat Ooredoo, Singtel Optus, Superloop	2019	4,850 km	Oceania
Google	Partial ownership	INDIGO-West	Australia's Academic and Research Network (AARNET), Indosat Ooredoo, Singtel Optus, Superloop	2019	4,600 km	Southeast Asia – Oceania
Amazon, Meta	Partial ownership	JUPITER	NTT, PCCW, PLDT, Softbank Corp	2020	14,557 km	East Asia – North America
Google	Sole owner	Curie		2020	10,476 km	North America – South America
Amazon, Google, Meta	Partial ownership (Google, Meta) major capacity	Havfrue/AEC-2	Aqua Comms, Bulk, Google, Meta	2020	7,650 km	North America – Europe

	buyer(amazon)					
Google	Partial ownership	Japan-Guam-Australia South (JGA-S)	Australia's Academic and Research Network (AARNET), RTI	2020	7,081 km	Oceania
Google	Sole owner	Dunant		2021	6,400 km	North America – Europe
Meta	Partial ownership	Malbec	V.tal	2021	2,600 km	South America
Google	Sole owner	Grace Hopper		2022	7,191 km	North America – Europe
Google, Meta	Partial ownership	Pacific Light Cable Network (PLCN)		2022	11,806 km	East Asia – North America
Meta	Partial ownership	Havhingsten/CeltixConnect-2	Aqua Comms, Bulk	2022	301 km	Europe
Meta	Partial ownership	Havhingsten/North Sea Connect	Aqua Comms, Bulk	2022	661 km	Europe
Google	Sole owner	Equiano		2023	15,000 km	Europe – Africa
Google	Sole owner	Firmina		2023	14,517 km	North America – South America
Google	Sole owner	Topaz		2023	NA	East Asia – North America
Meta	Partial ownership	2Africa	Bayobab, China Mobile, Orange, Saudi Telecom, Telecom Egypt, Vodafone, WIOCC	2023	45,000 km	Europe – Africa – Middle East – South Asia
Meta, Microsoft	Partial ownership	Amitie	Aqua Comms, Orange, Vodafone	2023	6,792 km	North America – Europe
Google, Meta	Partial ownership	Apricot	Chunghwa Telecom, NTT, PLDT	2024	11,972 km	Southeast Asia – East Asia
Google	Partial ownership	Blue	Omantel, Sparkle	2024	4,696 km	Eupore – Middle East
Google, Meta	Partial ownership	Echo		2024	17,184 km	Southeast Asia – North America
Google	Partial ownership	Raman	Omantel, Sparkle	2024	7,028 km	Middle East – South Asia
Meta	Sole owner	Anjana		2024	7,121 km	North America – Europe
Meta	Partial ownership	Bifrost	Keppel T&T, Telin	2024	19,888 km	Southeast Asia – North America
Meta	Partial ownership	Southeast Asia-Japan Cable 2 (SJC2)	China Mobile, Chunghwa Telecom, DongHwa Telecom, KDDI, SK Broadband, Singtel, Telin, True Corporation, VNPT-Vinaphone	2024	10,500 km	Southeast Asia – East Asia
Google	Sole owner	TPU		2025	13,470 km	East Asia – North America
Microsoft	Partial ownership	SeaMeWe-6	Bahrain Telecommunications Company (Batelco), Bangladesh Submarine Cable Company Limited (BSCCL), Bharti Airtel, China Unicom, Dhiraagu, Djibouti Telecom, Mobily, Orange, PCCW, Singtel, Sri Lanka Telecom, Telecom Egypt, Telekom Malaysia, Telin, Transworld	2025	21,700 km	Europe – Middle East – South Asia – Southeast Asia

Note: Blue coloured cells are either solely owned by a technology company or jointly owned by technology companies. The information is derived from the "Owners" section of the TeleGeography's Submarine Cable Map. Small or individual owners may not be listed on the Submarine Cable Map.

Source: TeleGeography (2023^[64]), *A Complete List of Content Providers' Submarine Cable Holdings*, TeleGeography (2023^[65]), *Submarine Cable Map*

Annex 1.D. Non-exhaustive list of public funding initiatives for broadband deployment in OECD countries

Annex Table 1.D.1. Non-exhaustive list of public funding initiatives for broadband deployment in OECD countries

Country	Year /Period	Name, total cost	Summary (objective, measures, target technology, etc)
Australia	2022-	AUD 2.4 billion (USD 1.7 billion)	AUD 2.4 billion (USD 1.7 billion) over four years provided to National Broadband Network (NBN) in the form of equity toward a commercial fibre upgrade within the fixed line network footprint (Light Reading, 2022 ^[166]).
	2022-	AUD 480 million (USD 333 million)	Provided a grant of AUD 480 million (USD 333 million) to NBN Co to upgrade the NBN fixed wireless network and to improve broadband and mobile coverage in regional area (Rowland, 2022 ^[167]).
	2022-	Better Connectivity Plan for Regional and Rural Australia 2023-2028 AUD 656 million (USD 455 million)	The Better Connectivity Plan is providing more than AUD 1.1 billion (USD 0.8 billion) to rural and regional communities. This commitment forms part of the Government's investment of more than AUD 2.2 billion (USD 1.5 billion) in regional communications. The Plan includes AUD 656 million (USD 455 million) provided in the 2022–23 October Budget over five years to improve mobile and broadband connectivity and resilience in rural and regional Australia. Initial funding allocations under the Plan include: AUD 400 million (USD 277 million) to boost multi-carrier mobile coverage on regional roads, improve mobile coverage in underserved regional and remote communities, and increase the resilience of communications services and public safety communications facilities; AUD 200 million (USD 139 million) for two additional rounds of the Regional Connectivity Program to invest in place-based digital connectivity infrastructure projects in regional communities; AUD 30 million (USD 21 million) for on-farm connectivity, so farmers can take advantage of connected machinery and sensor technology; AUD 20 million (USD 13 million) to conduct an independent audit of mobile coverage to better identify black spots and guide investment priorities; and AUD 6 million (USD 4 million) to boost funding for the Regional Tech Hub, which supports regional consumers to access advice and support on digital connectivity options (The Department of Infrastructure, Transport, Regional Development, Communications and the Arts, 2022 ^[168]).
	2022-	Initiative Broadband Austria 2030 EUR 1.4 billion (USD 1.47 billion)	EUR 1.4 billion (USD 1.47 billion) will be invested in the deployment of fibre in underserved regions. The funds derive from the Recovery and Resilience Facility - RRF (EUR 891 million (USD 938 million)), the proceeds of the 5G spectrum auctions (EUR 389 million (USD 409 million)) and additional EUR 166 million (USD 175 million) from the national budget. This measure addresses the Austrian backlog in the deployment of rural gigabit-capable access networks and therefore supports the objectives of the Austrian Broadband Strategy 2030 and the EU Gigabit objectives (European Commission, 2023 ^[169]).
Belgium	2022-	Project White Zone EUR 40.7 million (USD 42.8 million)	Subsidies awarded for fixed network in white areas, up to 50% of the cost of installing a very high-capacity network (VHCN) in currently underserved areas is covered (FPS Economy, 2022 ^[170]).
Canada	2015-	Connect to Innovate CAD 585 million (USD 457 million) (2015-2023)	This program aims to bring improved connectivity to rural and remote communities in Canada. Program funds are primarily directed to new backbone infrastructure to build connections to institutions like schools, hospitals and First Nations band offices. Backbone infrastructure is often fibre-based but can be comprised of a range of technologies including microwave, wireless and satellite service. eligibility included backbone capacity upgrades and resiliency, as well as last-mile infrastructure projects to

			households and businesses (Government of Canada, 2021 ^[171]).
	2015-2020	Connecting Canadians Program CAD 28 million (USD 22 million)	The Connecting Canadians program shares the costs of building broadband infrastructure that extends or enhances access to Internet of at least 5 Mbps in areas of slower or no service. With a target of connecting 280,000 households, Connecting Canadians provides non-repayable contributions toward the direct costs of selected projects (Government of Canada, 2020 ^[172]).
	2020-2024	CRTC Broadband Fund CAD 675 million (USD 503 million)	The CRTC Broadband Fund will provide up to CAD 675 million (USD 503 million) over the first five years to support projects that improve broadband Internet access services and mobile wireless services in underserved areas in Canada. It is designed to complement private sector investments and public sector initiatives. The funding comes from a levy on large Canadian telecommunications service providers with annual revenues (Office of the Auditor General of Canada, 2023 ^[173]).
		First Nations Infrastructure Fund CAD 75.6 million (USD 58 million)	The First Nation Infrastructure Fund (FNIF) helps First Nations communities upgrade and increase public infrastructure including broadband to improve the quality of life and the environment in First Nations communities (Government of Canada, 2022 ^[111]).
		Investing in Canada Infrastructure Program - Rural and Northern Communities Infrastructure Stream CAD 341 million (USD 262 million)	The Rural and Northern Communities stream supports projects that increase access to more efficient and reliable energy sources, improved physical conditions of community infrastructure, and improved internet connectivity for rural and northern communities (Government of Canada, 2022 ^[174]).
	2022-2031	CAD 600 million (USD 461 million)	CAD 600 million (USD 461 million) agreement between Canada government and Telesat enables Internet and mobility service providers to acquire Telesat LEO capacity at substantially reduced rates to bring universal broadband connectivity to rural, Northern and Indigenous communities across Canada. Under the terms of the agreement, a dedicated pool of Telesat LEO rural connectivity capacity will be available to Service Providers at greatly reduced rates on a first come, first served basis to provide connectivity for eligible communities. With Telesat LEO's high-performance network capacity, service providers will offer broadband services to their end users of at least 50/10 Mbps speeds with unlimited data, and mobility service providers will offer LTE services (Telesat, 2020 ^[175]).
	2015-	Small Communities Fund CAD 65.9 million (USD 51.5 million)	The Government of Canada provides funding to municipalities with less than 100,000 inhabitants through the Small Communities Fund (Government of Canada, 2020 ^[176]).
	2020-	Universal Broadband Fund CAD 3.225 billion (USD 2.4 billion)	The CAD 3.225 billion (USD 2.4 billion) Universal Broadband Fund supports high-speed Internet projects across the country. These projects will bring Internet at speeds of 50/10 Megabits per second (Mbps) to rural and remote communities. The funding includes: up to CAD 50 million (USD 37.3 million) for mobile Internet projects that primarily benefit Indigenous peoples, including projects along highways and roads where mobile connectivity is lacking; up to CAD 750 million (USD 559 million) for large, high-impact projects; The Universal Broadband Fund is part of the Government of Canada's coordinated plan to connect all Canadians: High-Speed Access for all: Canada's Connectivity Strategy (Government of Canada, 2022 ^[104]).
	2020-	Canada Infrastructure Bank CAD 2 billion (USD 1.5 billion)	The Canada Infrastructure Bank (CIB) is a federal crown corporation that provides low-cost loans to support a variety of infrastructure projects. The CIB has allocated CAD 2 billion (USD 1.5 billion) for broadband infrastructure projects (Canada Infrastructure Bank, 2020 ^[177]).
Chile	2021-	NATIONAL FIBRE OPTIC PROJECT (FON), the Telecommunications Development Fund (FDT) CLP 75 billion (USD 99 million)	With the objective of supporting the integral development of the country, the project called National Fibre Optic (FON) is being developed, which will make it possible to establish a terrestrial fibre connection between the communal capitals of the country and their respective regional capitals. National Fibre Optic Project (FON) is a part of part of the infrastructure subsidy program of the Telecommunications Development Fund (FDT). This Fund aims to promote coverage of telecommunication services in rural and low-income urban areas, with low to non-existent deployment of such services due to economic infeasibility of being provided or covered by the telecommunications market. This Fund does not carry the projects, but open public contests to institutions and companies so that they will propose a plan that meets conditions and obligations stated by the contest. The contestant who wins the contest, based on complying with all the conditions and obligations, gets their proposed project financed according to what was contested (Subtel, 2023 ^[178]).

Colombia		NATIONAL OPTICAL FIBRE PROJECT COP 433 billion (USD 102 million)	The Colombian territory has the implementation of the NATIONAL OPTICAL FIBRE PROJECT - PNFO, which aimed to expand the infrastructure of existing fibre networks, through the deployment of transport and access infrastructure in 788 new municipalities of the country located in 27 departments. The investment in the project amounted to more than COP 433 billion (USD 102 million).
		National Universal Access Project	In 2021, the majority of this funding (68.96%) was made on the National Universal Access Project, which includes the installation of 14,057 free Internet points for schools and surrounding communities in rural areas of the country, as well as their operation for ten years (Comisión de Regulación de Comunicaciones, 2022 ^[179]). The CRC reports a stark contrast between private and public investments in Colombia's telecommunications for 2021, with private investment reaching COP 7 trillion and public investment amounting to COP 198 billion.
Costa Rica	2021-	The execution of the Bicentennial Educational Network Program USD 170 million	Sutel began the execution of the Bicentennial Educational Network Program (REB) in 2021. This program is financed with the National Telecommunications Fund (Fonatel), and it seeks to provide connectivity to 2375 public schools in rural areas. The REB will cover 53% of public schools and 262 895 students. The public schools will connect to the Internet with speeds between 15 and 500 Mbps. The REB will subsidise the installation of the telecommunications infrastructure necessary to implement three levels: level 1 (connectivity services), level 2 (passive infrastructure) and level 3 (equipment of access switches, wireless access points). On March 2023, the REB had 607 public schools connected (Semanao Universidad, 2021 ^[180]).
Czech Republic	2014-2020	Operational Programme Enterprise and Innovation for Competitiveness (OP PIK 2014-2020) EUR 4.3 billion (USD 5.7 billion)	OP PIK (2014-2020) aimed to extend modern infrastructure of next generation networks and reliable provision of high-speed electronic communications services (Ministry of Industry and Trade, 2015 ^[181]).
	2021-2026	National Recovery Plan (NRP 2021-2026) EUR 227 million (USD 269 million)	In 2021, the Czech Recovery and Resilience Plan was approved by the European Commission, with 22% of the total EUR 7 billion in subsidies allocated for the digital transition. Component 1.3 of the plan outlines reforms and investments in connectivity, with a total budget of around EUR 227 million (USD 269 million). Examples of specific projects include providing internet access to remote homes, schools, businesses and government agencies, measuring and mapping network quality, and building 5G passive infrastructure in rural and railway corridors (European Commission, 2021 ^[182]).
	2022-2027	Operational Programme Technology and Applications for Competitiveness (OP TAC 2022-2027) EUR 3.2 billion (USD 3.4 billion)	OP TAC is a flagship programme for supporting Czech entrepreneurs in the 2021–2027 programming period. A total of EUR 3.2 billion (USD 3.4 billion) has been prepared for this operational programme from the European Regional Development Fund (ERDF). In this programme, call for broadband projects are included such as covering the white spots (investment-intensive rural locations) and construction of backhaul (API, 2023 ^[183]).
Estonia	2018-2023	First phase of broadband EUR 20 million (23.6 million)	It is a public tender for grant support, the purpose of which is to contribute to the construction of a passive broadband infrastructure of the access network, which enables the end user to use ultra-fast broadband service in areas where the service is currently unavailable or of insufficient quality and where Estonian communication operators do not plan to invest in the next five years (so-called white area) (Consumer Protection and Technical Regulatory Authority, 2023 ^[184]).
	2022-2025	Construction of a very high-capacity electronic communications access network EUR 24.29 million (USD 25.56 million)	The purpose of the grant is to contribute to the construction of a very high-capacity electronic communications access network in the eligible target area. The eligible target area of the supported activities consists of address objects where there is no fixed connection with a download speed of at least 30 megabits per second, and where it is not planned to be established with the investment of a communications company within the next three years. The budget is financed by the European Union from the resources of the NextGenerationEU regeneration fund (Riigi Tugiteenuste Keskus, 2023 ^[185]).
	2023-2024	Fourth phase of broadband (2023-2025) EUR 0.8 million (USD 0.84 million)	It is a pilot project within the framework of which local communities who want to establish a permanent high-speed Internet connection in rural areas received support. The total amount of grants is EUR 0.8 million (USD 0.84 million), and a total of eight applications were received, of which five received funding. A total of 100 new high-speed internet connections will be built. In order to receive support, a community initiative, a proper mapping of the interest of the inhabitants of the settlement unit and ensuring at least 50% coverage, suitability of the price range of the project and the ability to pay self-financing were necessary

			(Consumer Protection and Technical Regulatory Authority, 2023 ^[186]).
European Union	2018-	Connecting Europe Broadband Fund (CEBF) EUR 1-1.7 billion (USD 1.2-2 billion)	It invests in underserved areas where there are strong opportunities for profitability. Eligible countries to receive funding are EU Member States, Norway, Iceland and the United Kingdom. Its public investors include the European Investment Bank (EIB), the European Commission, and National Promotional Banks from France (Caisse des Dépôts), Germany (KfW), and Italy (Cassa depositi e prestiti) (European Commission, 2018 ^[187]).
	2021-2027	Connecting Europe Facility (CEF) - Digital EUR 1.6 billion (USD 1.9 billion)	It is part of the second generation of the Connecting Europe Facility and managed by the European Health and Digital Executive Agency (HaDEA). It aims to leverage public and private investments in digital connectivity infrastructures of common European interest (HaDEA, 2021 ^[188]).
	2021-	EU Recovery and Resilience Facility (RRF) EUR 723.8 billion (USD 856.6 billion)	The Recovery and Resilience Facility (RRF) is a temporary instrument that is the centrepiece of NextGenerationEU -the EU's plan to emerge stronger and more resilient from the current crisis. Reforms and investments aimed at improving connectivity are encouraged to be included in the Recovery and Resilience programme (RRP) (European Commission, 2021 ^[189]).
	2021-2027	Global Gateway EUR 300 billion (USD 355 billion)	It will invest to global infrastructure to boost smart, clean and secure links in digital, energy and transport sectors and to strengthen health, education and research systems across the world. It will be delivered through together the EU and EU Member States with their financial and development institutions, as well as private sector. It draws on the Neighbourhood, Development and International Cooperation Instrument (NDICI)-Global Europe, the Instrument for Pre-Accession Assistance (IPA) III, the digital and international part of the Connecting Europe Facility, but also Interreg, InvestEU and Horizon Europe (European Commission, 2021 ^[190]).
Finland	2022-	National Broadband State Aid Programme EUR 32 million (USD 33.7 million) (2022-2023)	The new broadband aid programme launched in 2022 will have Traficom grant state aid for the construction of fixed broadband connections offering minimum download speeds of 300 Mbps and upload speeds of 100 Mbps. Under this programme, aid can be granted for connections to be built for the permanent or holiday homes of households and the business locations of companies. The aid will be granted to broadband network builders selected based on regional tendering procedures. The funding comes from the EU's Recovery and Resilience Facility. The target is to achieve very high-capacity connectivity for at least 6 400 dwellings before the second half of 2024 and 16 000 dwellings in commercially challenging areas before the second half of 2026 (TRAFICOM, 2022 ^[108]).
France	2013-2022	EUR 12.9 billion (USD 17.1 billion)	The total amount of public investment for projects supported under the very high-speed France plan is EUR 12.9 billion (USD 17.1 billion) for the period 2013-2022, including EUR 3.51 billion (USD 4.66 billion) from the State (France Stratégie, 2023 ^[191]).
	2022-2025	EUR 570 million (USD 600 million)	EUR 570 million (USD 600 million) will be mobilized to strengthen the France Very High-Speed Plan. EUR 420 million (USD 442 million) were specifically earmarked for RIPv which did not yet have a funded project to ensure the generalization of fibre. The remaining EUR 150 million (USD 158 million) are intended for a system whose aim is to overcome the practical difficulties of connecting to optical fibre by ensuring everyone has the conditions for effective access to fibre.
Germany	2015-	The German fibre funding scheme EUR 17 billion (18.9 billion) (including the Gigabit Funding 2.0, 2023-)	The German fibre funding scheme was initiated in 2015. Germany currently provides around EUR 17 billion to support broadband expansion. Around EUR 13 billion are already bound. For the year 2023, the federal government provides more than EUR 3 billion (USD 3.1 billion) for approvals under the funding scheme. The Federal Government awards grants to the municipalities whereas the telecommunications companies take part in a tender process, initiated by the municipalities (BMDV, 2023 ^[109]).
	2021-	The Federal Mobile Funding Scheme with a total budget of EUR 1.1 billion (USD 1.3 billion)	The Federal Mobile Funding Scheme with a total budget of EUR 1.1 billion (USD 1.3 billion) aims to ensure 5G-capable funded mobile sites with at least 4G-coverage in white spots that currently have no or only 2G connectivity. As for the Federal Mobile Funding Scheme, funding is allocated in the form of grants. The mobile funding scheme addresses companies, who are specialised in building mobile sites, i.e. tower companies (BMDV, 2021 ^[120])
Greece	2023-2025	Programme "Smart Readiness" EUR 100 million (USD 105 million)	The "Smart Readiness" Program subsidises the implementation of works related to the installation of infrastructure that will facilitate the transformation of a building into a "smart" one, as well as its interconnection with utility networks (electricity, natural gas) through new "smart" meters. It is financed from National Recovery and Resilience Fund (Ελλάδα 2.0, 2023 ^[115]).
	2023-	Ultra-Fast Broadband Infrastructure project	The project "Ultra-Fast Broadband Infrastructure" (UFBB) is a Public-Private Partnership (PPP) project, which will ensure the possibility of ultra-high-speed Internet in areas that

		EUR 870 million (USD 916 million)	were not included in the planning of private investments. This project has an initial budget of EUR 870 million (USD 916 million) including VAT. Of this, EUR 300 million (USD 316 million) is co-financed public expenditure, which is covered by the Structural and Investment Funds of the European Union, and the rest will be covered by private funds (Ministry of Digital Governance, 2023 ^[125]).
Hungary		Gigabit Hungary network deployment program	The Hungarian Government launched the Superfast Internet Programme in 2015. It aimed at covering 95% of the households with NGA. The programme has been closed at the end of 2023 reaching out 96% of the households. Thanks to the project's evaluation criteria system, 88% of the NGA coverage technology was optical-based (FTTH p2p, FTTH pmp), so this part of the upgrades provides gigabit transmission speed. The Gigabit Hungary network deployment program which commences in 2024 is in preparation. The aim of the program to deliver Gigabit connections to the households where the 1 Gbps connection is not available using public funding. The program also considers the option for 5G networks funded partly by the EU CEF2 Digital program. The network to be deployed should use FTTH technology and 5G based FWA.
Iceland	2016-2021	The rural fibre program ISK 3.5 billion (USD 29 million)	The rural fibre program was in place 2016-2021 where around 6,300 homes and businesses got access to fibre. The program was organised and financed by The Telecommunications Fund (fjarskiptasjóður) on behalf of the government. Co-funding was made available to all municipalities in Iceland for fibre roll-out in rural areas. Total cost was estimated to be around ISK 7 billion (USD 58 million) of which the government granted around ISK 3.5 billion (USD 29 million) (Government of Iceland, 2020 ^[192]).
	2019-	the National Broadband Plan EUR 2.7 billion (USD 3 billion)	The National Broadband Plan is the government's initiative to deliver high-speed broadband services to all premises in Ireland. This will be delivered through investment by commercial enterprises coupled with intervention by the State in those parts of the country where private companies have no plans to invest. The State Intervention area includes over 560,000 premises, 1.1 million people, over 65,000 farms, 44,000 non-farm businesses, and 679 schools. The maximum possible cost to the State will be EUR 2.7 billion (USD 3 billion) over 25 years (Government of Ireland, 2020 ^[193]).
Italy	2021-	Ultra Broadband Strategy EUR 6.7 billion (USD 7.9 billion)	The National Strategy for Ultra Broadband aims to bring connectivity to 1 Gbps throughout the country by 2026 and encourage the development of fixed and mobile telecommunications infrastructures, as indicated by the National Recovery and Resilience Plan (PNRR). The PNRR allocates 27% of resources to the digital transition, of which EUR 6.7 billion (USD 7.9 billion) for the projects that make up the present Strategy for Ultra-Broadband. The Strategy includes these interventions: 1. "ITALY TO 1 GIGA" PLAN aims to provide residential units with at least 1 Gbit/s download and 200 Mbit/s upload connections. A tender was held in 2022 and EUR 3.4 billion (USD 3.6 billion) was allocated. 2. "ITALY 5G" PLAN It aims to accelerate the deployment of 5G mobile networks in unprofitable regions. EUR 2.02 billion (USD 2.13 billion) will be allocated to the plan, which consists of two plans to provide investment incentives of up to 90% for the construction of fibre backhaul for mobile networks and the construction of high-density new mobile networks. 3. "CONNECTED SCHOOLS" PLAN Provide at least 1 Gbps internet access to all schools nationwide. Around EUR 166 million (174.7 million) was provided in 2022. 4. "CONNECTED HEALTHCARE" PLAN It aims to guarantee connections at symmetrical speeds of at least 1 Gbps and up to 10 Gbps for healthcare facilities. EUR 314 million (USD 331 million) was provided in 2022. 5. "LESSER ISLANDS" PLAN It aims to provide adequate connectivity to small islands that lack fibre connections to the mainland, EUR 45 million (USD 47 million) was provided in 2022. 6. COMPLETION OF THE "WHITE AREAS" PLAN EUR 1.3 billion (USD 1.37 billion) was allocated for bringing high-speed internet to "white areas" where fixed connections perform poorly (Dipartimento per la Trasformazione Digitale, 2022 ^[101]).
Japan	2023-	Project to Promote Advanced Wireless Environment JPY 4.2 billion (USD 31.9 million)	This project is a measure by which the government subsidises part of the deployment costs for transmission line facilities etc. in geographically disadvantaged areas where there is no prospect of voluntary deploy by the private sector because profitability cannot be expected. In the 2023 fiscal year, budget of approximately JPY 4.2 billion (USD 31.9 million) have been prepared.

			Subsidies are being provided for the development of 5G base stations and other facilities by local governments and mobile phone operators in areas where conditions are unfavourable (MIC, 2023 ^[118]).
Latvia	2021-	Latvia's Recovery and Resilience Facility Plan EUR 16.85 million (USD 20 million)	Latvia's Recovery and Resilience Facility Plan (RRF): State aid program "Construction of Passive Infrastructure in the Via Baltica Corridor to Ensure 5G Coverage". The project will create a passive electronic communication infrastructure (optical cable network, mobile communication towers and power line connections), which will support the provision of continuous 5G coverage of the mobile communication network on the Via Baltica road in the territory of Latvia. EUR 12.5 million (USD 14.8 million) – RRF (100%); EUR 4.35 million (USD 5.15 million) – ERDF (85%) and private co-financing (15%).
	2021-	State aid program "Development of Broadband or Very High-Performance Networks' "Last Mile" Infrastructure" EUR 12.7 million (USD 15 million)	The project envisages that an electronic communications provider selected as a result of an open tender will create very high-performance network "last mile" (at least 100 Mbit/s) connections to households, companies, schools, hospitals and other public buildings. EUR 4 million (USD 4.7 million) – RRF (100%); EUR 8.7 million (USD 10.3 million) – ERDF (85%) and co-financing (15%).
	2021-2027	Project "Development of the infrastructure of electronic communication networks "middle mile" EUR 13.05 million (USD 15.4 million)	Project "Development of the infrastructure of electronic communication networks "middle mile"". 2021-2027 ERDF EUR 13.05 million. Support is intended for the creation of very high-performance electronic communications network (with a data transmission speed of at least 100 Mbit/s) infrastructure, including backhaul ("middle mile") and "last mile".
	2021-2027	Project "Construction of 5G supporting infrastructure in the Rail Baltica corridor" EUR 8.265 million (USD 9.78 million).	Project "Construction of 5G supporting infrastructure in the Rail Baltica corridor". The support is intended for the construction of passive electronic communication infrastructure (optical cable networks, mobile communication node points) and energy supply networks, which will support the provision of continuous 5G coverage in the Rail Baltica corridor on the territory of Latvia. 2021-2027 ERDF EUR 8.265 million (USD 9.78 million).
Lithuania	2021-2027	National Broadband Plan (for gigabit broadband infrastructure) EUR 49 million (USD 58 million)	This plan pledges EUR 49 million (USD 58 million) provided by EU Recovery and Resilience Facility funds for Infrastructure investments, including the building of 50 new towers, rolling out 2,000 km of fibre and related active equipment with appropriate maintenance and administration.
	2021-2027	National Broadband Plan (for white area) EUR 25 million (USD 29.6 million)	At least 100 Mbps speed broadband communication infrastructure implementation in the "white" rural areas of the country by building communication towers and laying fibre lines by 2027. It is funded from European Regional Development Fund (ERDF) funding.
Mexico	2022-	Cobertura Social 2022-2023	The government program "Cobertura Social 2022-2023" considers vulnerable areas (low income and remote locations) and groups (low income, indigenous, afro-mexican). This program is aligned with the priority objectives established by the Secretaría de Infraestructura, Comunicaciones y Transportes (Infrastructure, Communications and Transport Ministry) in the "Programa Sectorial de Comunicaciones y Transportes 2020-2024", which in turn is based on the National Development Plan 2019-2024 (DOF, 2023 ^[112]).
New Zealand	2011-2023	Ultra-Fast Broadband (UFB) programme NZD 1.785 billion (USD 1.4 billion)	The government-funded programme of providing fibre to over 410 cities and towns and key institutions (schools, hospitals, medical centres) rolled out between 2011 and 2023 (Ministry of Business, Innovation & Employment, 2022 ^[194]).
	2010-	Rural Broadband Initiatives (RBI) Phase 1 NZD 300 million (USD 216 million)	The government-funded programme providing enhanced broadband in rural areas. RBI Phase Two aims to provide approximately 84,000 rural houses and businesses rolled out by the end of 2023 (Ministry of Business, Innovation & Employment, 2022 ^[194]).
	2016-2023	Mobile Black Spot Fund (MBSF) and Rural Broadband Initiative Phase 2 (RBI2) NZD 297 million (USD 207 million)	The government-funded programme to improve availability of mobile services on state highways and tourism sites from 2016-2023. By the end of 2023, approximately 1,400km of state highways and over 168 tourism sites will receive mobile coverage.
	2019-	Regional connectivity initiative: Marae Digital Connectivity (MDC) NZD 23.9 million (USD 15.7 million)	The Marae Digital Connectivity programme takes the form of grants, made upon the assessment of applications from eligible marae (Crown Infrastructure Partners Limited, 2022 ^[102]).

Norway	2014-	broadband support scheme (Nkom fund) NOK 304.6 million (USD 31.7 million) (2022)	Nkom fund, public support for broadband development granted from the state budget, are distributed to the county municipalities. This scheme is a means of stimulating the development of broadband in areas where it is not commercially profitable to develop digital infrastructure. In such areas, the state, county council and municipality can, according to given criteria, provide public subsidies for the development of broadband. The procurement process to find a provider to develop and operate the infrastructure will be conducted through tenders (Nkom, 2023 _[105]).
Poland	2023-	Increasing access to ultra-fast broadband Internet PLN 2.9 billion (USD 651 million)	Under the project on expanding access to ultra-high-speed broadband Internet, telecommunications operators can apply for funding to build broadband networks with a capacity of at least 300 Mb/s in areas where Internet access is difficult. It has been allocated PLN 2.9 billion (USD 651 million) by the European Digital Development Fund (gov.pl, 2023 _[195]).
	2023-	Providing access to very fast internet in areas of white spots PLN 4.2 billion (USD 942 million)	Under the project on providing ultra-high-speed internet access in white spot areas, operators can apply for funding for the construction of broadband networks to ensure high-speed internet access in the "white spot." PLN 4.2 billion (USD 942 million) has been allocated based on the National Recovery Plan Fund (gov.pl, 2023 _[196]).
Portugal	2023-2024	The National Strategy for Connectivity in Very High-Capacity Electronic Communications Networks 2023-2030 EUR 172 million (USD 181 million)	The Portuguese Government launched in December 2023 a public tender for the deployment of very high-capacity electronic communications networks (VHCN) for covering the 'white areas'. The measure aims to promote investments in the deployment of fixed access networks providing to all households, as well as to all industrial, commercial, and agricultural premises, connectivity of at least 1 Gbps download speed and 150 Mbps upload speed (the target speeds) in areas of the Portuguese territory where the networks already present and/or credibly planned in a relevant time horizon of six years do not, and will not, provide the target speeds (Diário da República, 2022 _[197]) (ANACOM, 2023 _[198]). Under the scheme, the aid will take the form of direct grants that will be awarded to operators following a tender procedure. The aid will cover up to 100% of the eligible costs. (European Commission, 2023 _[199]).
Slovak Republic	2021-	Programme Slovakia EUR 112 million (USD 133 million)	Slovakia plans to support private sector investment and achieve connectivity goals through the Programme Slovakia, where in measure 1.5.1 Digital Connectivity – EUR 112 million (USD 133 million) is allocated until 2030 (Eurofondy, 2021 _[200])
Slovenia		Co-financed the construction of open BB networks Total EUR 82 million (USD 112 million) (2007 – 2013) and total EUR 27.8 million (USD 36.9 million) (2014 – 2020) from the European Regional Development Fund Total EUR 3.7 million (USD 5 million) (2007-2013) and total EUR 9.9 million (USD 13.1 million) (2014 - 2020) from the European Agricultural Fund for Rural Development	Since 2008, the Republic of Slovenia has been co-financing the construction of broadband (BB) networks on white spots from cohesion policy funds in those areas where operators have no market interest. In the initial projects on the beginning, co-financing took place based on a public-private partnership. From 2020 onwards, co-financing is established between the ministry and the investor/electronic communications operator as permitted state aid, so the following conditions must be cumulatively met: <ul style="list-style-type: none"> o The area is not sufficiently covered by the BB network o There is no market interest in building the network in the next three years o The BB network must be open o Transparent and non-discriminatory competitive procedures for the selection of network contractors while respecting the principle of technology neutrality (The Ministry of Education, Science, and Sport, 2016_[124])
Spain	2018-	UNICO Broadband Program EUR 1,508 million (USD 1,780 million)	Since 2018, the UNICO Broadband Program and its predecessor the PEBA Plan have provided EUR 900 million (USD 947 million) in public aid, mobilizing investments of a combined EUR 1,508 million (USD 1,780 million) to cover 4.73 million homes with ultra-fast broadband networks. The objective of the measure UNICO Broadband in its calls is to deploy infrastructures that enable the provision of 300 Mbps services, symmetrical and scalable to 1Gbps (Espana digital, 2021 _[201]).
	2022-	UNICO 5G Backhaul Networks (Optical Fibre) EUR 450 million (USD 474 million)	This measure is intended to ensure that eligible base stations ("BTSs") are provided with a fibre-based backhaul connection, so that it can facilitate the provision of new high-performance mobile services and application, including those enabled by 5G technology, which will be offered from those BTSs. The measure is aimed at base stations located in municipalities with less than 10,000 inhabitants to facilitate the provision of these new services and applications that enhance their economic development, although the call was limited to municipalities with less than 5,000 inhabitants to improve the impact of the measure. This call corresponds to RRP Component 15 investment 6: "Deployment of 5G networks and 5G innovations" of RRP Component 15 (Espana digital, 2022 _[202]).
	2023-	UNICO 5G Redes Activas more than EUR 500 million (USD 526 million)	It is a granting of aid for the provision of the set of active equipment and auxiliary infrastructure necessary for the provision of mobile communications services with 5G technology in areas where there is no 4G mobile coverage with a minimum service of 50

			Mbps. The program will have a budget of more than EUR 500 million (USD 526 million) to deploy the necessary equipment for 5G services in municipalities with less than 10,000 inhabitants. In July 2023, the first call of the program will be launched (Ministerio de Asuntos Económicos y Transformación Digital, 2020 ^[203]).
Sweden		state aid program for broadband infrastructure investments (gigabit connectivity) just over SEK 2.9 billion (USD 315 million) (2020-2022) approximately SEK 5.1 billion (USD 504 million) (2023-2027)	PTS is responsible for the state aid program for broadband infrastructure investments (gigabit connectivity). Using data from PTS's geographic broadband survey, a list is drawn up of all buildings in Sweden that are eligible for funding that year. The funds are then distributed through a tender procedure. Applicants (broadband network operators) submit applications stating which buildings they intend to connect and at what cost. Funding is allocated to the applicants and the projects that meet the terms and conditions of the program and that are most cost-effective. The program is partly funded by the EU Recovery and Resilience Facility (RRF) (European Commission, 2023 ^[204]).
Republic of Türkiye			The Turkish government has allocated public funds to support the expansion of high-capacity broadband infrastructure. This includes investment in fibre networks, and mobile broadband networks particularly in underserved regions, to improve broadband access and connectivity.
	2017-2020	National Broadband Strategy and Action Plan	With the National Broadband Strategy and Action Plan (2017-2020), 25 different actions were planned between 2017 and 2020 under three strategic aims (to increase supply, to increase demand, and to increase both supply and demand). The strategy sets broadband targets for 2023 as well (HGM, 2017 ^[205]).
	2024-2028	The 12 th Development Plan	The 12 th Development Plan published in the Official Gazette dated 1 November 2023 contains the following policy measures for ICT sector (Ekim, 2023 ^[206]); - expansion of fixed and mobile broadband infrastructures that offer high-speed, high-quality, secure and affordable access. - establishment and operation of broadband infrastructures in regions that cannot be reached commercially by state support, among others.
	2023-	The Call for Supporting the 5th Generation (5G) Mobile Communication Infrastructure Development Projects	"Program for Supporting the 5th Generation (5G) Mobile Communication Infrastructure Development Projects" aims to encourage domestic and national manufacturing for all products needed for 5G infrastructure. Within the framework of the program, it is planned to provide approximately 200 million TL R&D support (BTK, 2023 ^[207]).
United Kingdom	2022-	Project Gigabit GBP 5 billion (USD 6.41 billion)	The Government has promised GBP 5 billion (USD 6.41 billion) to subsidise the roll-out of gigabit-broadband to the 'hardest to reach' premises in the country that will not be reached by private investment (20% of the UK), mostly in rural areas. Project Gigabit has three main parts: -A series of procurements subsidising the roll-out of gigabit-capable broadband in specific areas. Broadband suppliers bid for contracts to build in each area. -A voucher scheme for residents and businesses in eligible rural areas to subsidise the cost of a new gigabit-capable connection. -Funding to connect public sector buildings such as schools (called 'GigaHubs') (GOV.UK, 2023 ^[103]).
	2020-	Shared Rural Network (SRN) GBP 500 million (USD 641 million)	The Shared Rural Network (SRN) will deliver reliable mobile broadband to 95% of the United Kingdom, addressing the digital divide by improving 4G coverage in the areas that need it most. By upgrading their existing networks and working together on shared infrastructure and new sites, the MNOs and Government will transform mobile coverage in rural areas. To deliver the programme, MNOs will invest GBP 532 million (USD 682 million) to eliminate the majority of 'partial not-spots' – areas which receive coverage from at least one, but not all, operators. The United Kingdom government will provide a further GBP 500 million (USD 641 million) to build new masts to eliminate 'total not-spots' – hard to reach areas where there is currently no coverage at all (Shared Rural Network, 2020 ^[208]).
United States		Broadband Equity, Access, and Deployment (BEAD) program 2023 USD 42.45 billion	The National Telecommunications and Information Administration (NTIA) of the Department of Commerce provides a funding to all 50 states, the District of Columbia, and five territories to bring affordable, reliable, high-speed Internet service to everyone in the United States. This funding supports infrastructure deployment, mapping and implementation. This includes planning and capacity building in state government agencies. This aims to expand Internet access to these priority areas: Unserved locations (No access to 25/3 Mbps), Underserved locations (No access to 100/20 Mbps) (Internet for All, 2023 ^[117])
	2021-	Tribal Broadband Connectivity Program Round 1 USD 3 billion	It supports Tribal governments bringing high-speed Internet to Tribal lands, including telehealth, distance learning, affordability, and digital inclusion initiatives (NTIA, 2023 ^[113]).

2023-	Tribal Broadband Connectivity Program Round 2 USD 980 million	It makes available on Native American, Alaska Native and Native Hawaiian lands for deployment of Internet infrastructure, affordability programs, telehealth and distance learning initiatives (NTIA, 2023 ^[113]).
	FCC's High Cost program USD 87.5 billion (2001-2021)	The High Cost program provides monetary support to providers of telecommunications services to allow for the provision of voice and broadband services at reasonable prices in rural and insular areas that, due to low population density, difficult terrain, and other factors, might otherwise be prohibitively expensive to serve. From 2001-2021 the FCC's High Cost program has distributed approximately USD 87.5 billion. The program has an annual budget of approximately USD 4.5 billion (FCC, 2023 ^[209])

Note: Exchange rates from OECD.stat have been used for the year in which the funding was granted. If the funding spans multiple years, the exchange rate of the first year was used. If the funding duration is unknown or the funding was granted in 2023, the exchange rate for 2022 was used.

Source: OECD elaboration based on the responses to the CISP DEO 2024 Regulatory Questionnaire

References

- ACCC (2022), *Telstra Corporation Limited and TPG Telecom Limited proposed spectrum sharing*, <https://www.accc.gov.au/public-registers/mergers-registers/merger-authorisations-register/telstra-corporation-limited-and-tpg-telecom-limited-proposed-spectrum-sharing> (accessed on 9 October 2023). [16]
- Amazon (2023), *Announcing a new \$7.8 billion investment enabling our continued growth and creating new job opportunities in the Buckeye State.*, <https://www.aboutamazon.com/news/aws/aws-continues-to-invest-in-ohio> (accessed on 9 August 2023). [43]
- Amazon (2023), *AWS in your community: Here's what's happening in eastern Oregon*, <https://www.aboutamazon.com/news/aws/aws-data-centers-eastern-oregon> (accessed on 9 August 2023). [45]
- Amazon (2023), *AWS Launches Infrastructure Region in Israel*, <https://press.aboutamazon.com/2023/8/aws-launches-infrastructure-region-in-israel> (accessed on 9 August 2023). [35]
- Amazon (2023), *AWS Launches Second Infrastructure Region in Australia*, <https://press.aboutamazon.com/2023/1/aws-launches-second-infrastructure-region-in-australia> (accessed on 9 August 2023). [36]
- Amazon (2023), *AWS to Launch an Infrastructure Region in Malaysia*, <https://press.aboutamazon.com/2023/3/aws-to-launch-an-infrastructure-region-in-malaysia> (accessed on 9 August 2023). [37]
- Amazon (2023), *Everything you need to know about Project Kuiper, Amazon's satellite broadband network*, <https://www.aboutamazon.com/news/innovation-at-amazon/what-is-amazon-project-kuiper> (accessed on 9 August 2023). [72]
- Amazon (2023), *Learn about AWS's long-term commitment to Virginia*, <https://www.aboutamazon.com/news/aws/aws-commitment-to-virginia> (accessed on 9 August 2023). [44]
- Amazon (2022), *AWS Launches Infrastructure Region in Spain*, <https://press.aboutamazon.com/2022/11/aws-launches-infrastructure-region-in-spain> (accessed on 9 August 2023). [39]
- Amazon (2022), *AWS Launches Infrastructure Region in Switzerland*, <https://press.aboutamazon.com/2022/11/aws-launches-infrastructure-region-in-switzerland> (accessed on 9 August 2023). [40]
- Amazon (2022), *AWS Launches Region in the United Arab Emirates*, <https://press.aboutamazon.com/2022/8/aws-launches-region-in-the-united-arab-emirates> (accessed on 9 August 2023). [42]

- Amazon (2022), *AWS Launches Second Infrastructure Region in India*, [38]
<https://press.aboutamazon.com/2022/11/aws-launches-second-infrastructure-region-in-india>
 (accessed on 9 August 2023).
- Amazon (2022), *AWS to Launch an Infrastructure Region in Thailand*, [41]
<https://press.aboutamazon.com/2022/10/aws-to-launch-an-infrastructure-region-in-thailand>
 (accessed on 9 August 2023).
- American Tower (2020), *American Tower Announces Agreement to Acquire InSite Wireless Group*, [161]
<https://www.businesswire.com/news/home/20201105005163/en/American-Tower-Announces-Agreement-to-Acquire-InSite-Wireless-Group> (accessed on 9 October 2023).
- ANACOM (2023), *Telecomunicações e acesso à Internet de qualidade finalmente uma realidade em todo o País*, [198]
<https://www.anacom.pt/render.jsp?contentId=1769445> (accessed on 30 January 2024).
- Analysys Mason (2022), *The impact of tech companies' network investment on the economics of broadband ISPs*, [29]
<https://www.analysismason.com/consulting/reports/internet-content-application-providers-infrastructure-investment-2022/> (accessed on 8 August 2023).
- APC (2020), *Expanding the telecommunications operators ecosystem: Policy and regulatory guidelines to enable local operators* | Association for Progressive Communications, [129]
<https://www.apc.org/en/pubs/expanding-telecommunications-operators-ecosystem-policy-and-regulatory-guidelines-enable-local> (accessed on 9 March 2021).
- API (2023), *The Operational Program Technologies and Application for Competitiveness (OP TAC) 2021 – 2027*, [183]
<https://www.agentura-api.org/en/op-tak/> (accessed on 8 September 2023).
- Apple (2022), *Emergency SOS via satellite on iPhone 14 and iPhone 14 Pro lineups made possible by \$450 million Apple investment in US infrastructure*, [74]
<https://www.apple.com/newsroom/2022/11/emergency-sos-via-satellite-made-possible-by-450m-apple-investment/> (accessed on 9 August 2023).
- Arab News (2023), *Saudi Telecom's TAWAL secures \$1.42bn funding for European tower asset acquisition*, [156]
<https://www.arabnews.com/node/2362306/business-economy> (accessed on 9 October 2023).
- ARN (2021), *ACCC says 'I told you so' over TPG-Vodafone merger*, [14]
<https://www.arnnet.com.au/article/689207/accs-says-told-over-tpg-vodafone-merger/>
 (accessed on 9 October 2023).
- AWS (2023), *Amazon CloudFront Key Features*, [57]
https://aws.amazon.com/cloudfront/features/?nc1=h_ls&whats-new-cloudfront.sort-by=item.additionalFields.postDateTIme&whats-new-cloudfront.sort-order=desc (accessed on 9 August 2023).
- AWS (2023), *AWS Global Infrastructure*, [34]
<https://aws.amazon.com/about-aws/global-infrastructure/> (accessed on 9 August 2023).
- AWS (2023), *https://pages.awscloud.com/GLOBAL-other-DL-Transformation-with-AWS-whitepaper-2023-learn.html*, [77]
<https://pages.awscloud.com/GLOBAL-other-DL-Transformation-with-AWS-whitepaper-2023-learn.html> (accessed on 9 August 2023).

- AWS (2023), *Regions and Zones*, [212]
<https://docs.aws.amazon.com/AWSEC2/latest/UserGuide/using-regions-availability-zones.html> (accessed on 9 October 2023).
- Bain & Company (2023), *M&A Report 2023*, [88]
<https://www.bain.com/insights/topics/m-and-a-report/>.
- BBC (2024), *Facebook's first dividend stands to make a few very rich*, [6]
<https://www.bbc.com/worklife/article/20240205-facebook-meta-first-dividend-after-2023-layoffs-ai-and-metaverse#:~:text=According%20to%20the%20February%20press,payment%20on%2026%20March%2C%202024>. (accessed on 6 February 2024).
- BMDV (2023), *Die Gigabitförderung 2.0*, [109]
<https://bmdv.bund.de/SharedDocs/DE/Artikel/DG/relaunch-des-breitbandfoerderprogramms.html> (accessed on 28 August 2023).
- BMDV (2021), *Mobilfunkförderung*, [120]
<https://bmdv.bund.de/SharedDocs/DE/Artikel/DG/foerderprogramm-mobilfunkfoerderung.html> (accessed on 28 August 2023).
- BNamericas (2022), *Spin-off of América Móvil's tower business close to completion*, [150]
<https://www.bnamericas.com/en/news/spin-off-of-america-movils-tower-business-close-to-completion> (accessed on 9 October 2023).
- bnamericas (2023), *BTG Pactual funds up stake in telecom wholesaler V.tal*, [95]
<https://www.bnamericas.com/en/news/btg-pactual-funds-up-stake-in-telecom-wholesaler-vtal> (accessed on 6 October 2023).
- Brookfield (2023), *Infrastructure*, [25]
<https://www.brookfield.com/our-businesses/infrastructure> (accessed on 9 October 2023).
- BTK (2023), *5. Nesil (5G) Mobil Haberleşme Altyapısının Geliştirme Projelerinin Lansman Töreni BTK'da Düzenlendi (The Launch Ceremony of the 5th Generation (5G) Mobile Communication Infrastructure Development Projects was Held at BTK)*, [207]
<https://www.btk.gov.tr/haberler/5-nesil-5g-mobil-haberlesme-altyapisinin-gelistirme-projelerinin-lansman-toreni-btk-da-duzenlendi> (accessed on 14 December 2023).
- Canada Infrastructure Bank (2020), *Prime Minister announces infrastructure plan to create jobs and grow the economy*, [177]
<https://cib-bic.ca/en/medias/articles/prime-minister-announces-infrastructure-plan-to-create-jobs-and-grow-the-economy/> (accessed on 8 September 2023).
- Capacity Media (2023), *Inside the world of TMT Investment Banking*, [20]
<https://www.capacitymedia.com/article/2c2nwijov4f4pk18r86ww/big-interview/inside-the-world-of-tmt-investment-banking> (accessed on 9 October 2023).
- Carlyle (2022), *Carlyle Partners with Tillman Global Holdings, Commits up to \$1 Billion to Accelerate Investments in US Towers*, [163]
<https://www.carlyle.com/media-room/news-release-archive/carlyle-partners-with-tillman-global-holdings-commits-up-to-1-billion-to-accelerate-investments-in-us-towers> (accessed on 9 October 2023).
- Cellnex (2023), *Endless opportunities through telecom connectivity*, [27]
<https://www.cellnex.com> (accessed on 9 October 2023).

- Cellnex (2020), *Agreement between Cellnex and Bouygues Telecom to invest € 1 billion over the next 7 years*, <https://www.cellnex.com/news/cellnex-bouygues-telecom-invest-1-billion/> (accessed on 9 October 2023). [28]
- Comisión de Regulación de Comunicaciones (2022), *Data Flash 2022-027 - Observatorio de inversión en telecomunicaciones*, <https://postdata.gov.co/dataflash/data-flash-2022-027-observatorio-de-inversion-en-telecomunicaciones> (accessed on 8 September 2023). [179]
- Connecting Africa (2021), *Liquid, Facebook partner on fiber project in DRC*, https://www.connectingafrica.com/document.asp?doc_id=770699 (accessed on 29 September 2023). [70]
- Consumer Protection and Technical Regulatory Authority (2023), *Fourth phase of broadband (2023-2025)*, <https://www.ttja.ee/lairiba-neljas-etapp-2023-2025> (accessed on 8 September 2023). [186]
- Consumer Protection and Technical Regulatory Authority (2023), *Lairiba esimene etapp (alates 2017)*, <https://www.ttja.ee/lairiba-esimene-etapp-alates-2017> (accessed on 8 September 2023). [184]
- CoreSite (2021), *American Tower to Acquire CoreSite*, <https://www.coresite.com/newsroom/american-tower-acquire-coresite> (accessed on 9 October 2023). [162]
- CRN (2021), *Telstra InfraCo Towers renamed 'Amplitel' after \$2.8b sale*, <https://www.crn.com.au/news/telstra-infraco-towers-renamed-amplitel-after-28b-sale-569316> (accessed on 9 October 2023). [133]
- Crown Infrastructure Partners Limited (2022), *Rural Capacity Upgrades*, <https://www.crowninfrastructure.govt.nz/rural/rural-capacity-upgrades-rcu/> (accessed on 28 August 2023). [102]
- CRTC (2023), *CRTC takes action to ensure Canadians have more choice of cellphone services*, https://www.canada.ca/en/radio-television-telecommunications/news/2023/05/crtc-takes-action-to-ensure-canadians-have-more-choice-of-cellphone-services.html?utm_source=miragenews&utm_medium=miragenews&utm_campaign=news (accessed on 9 October 2023). [12]
- CRTC (2023), *Wholesale mobile virtual network operator (MVNO) access tariffs – Amended terms and conditions*, https://crtc.gc.ca/eng/archive/2023/2023-133.htm?_ga=2.257591755.1507339952.1693198193-1946988240.1693198193 (accessed on 9 October 2023). [13]
- Data center dynamics (2023), *https://www.datacenterdynamics.com/en/news/regulator-tells-oi-it-cant-sell-stake-in-brazilian-fiber-firm-vtal/*, <https://www.datacenterdynamics.com/en/news/regulator-tells-oi-it-cant-sell-stake-in-brazilian-fiber-firm-vtal/> (accessed on 6 October 2023). [96]
- DCD (2023), *American Tower considers selling its India tower business*, <https://www.datacenterdynamics.com/en/news/american-tower-considers-selling-its-india-tower-business/> (accessed on 9 October 2023). [23]

- DCD (2023), *American Tower to exit Poland*, [155]
<https://www.datacenterdynamics.com/en/news/american-tower-to-exit-poland/> (accessed on 9 October 2023).
- DCD (2023), *Cellnex ponders sale of stake in Nordic operations*, [160]
<https://www.datacenterdynamics.com/en/news/cellnex-ponders-sale-of-stake-in-nordic-operations/> (accessed on 9 October 2023).
- DCD (2023), *Vodafone nets half a billion euros from latest Vantage Towers sale*, [159]
<https://www.datacenterdynamics.com/en/news/vodafone-nets-half-a-billion-euros-from-latest-vantage-towers-sale/> (accessed on 9 October 2023).
- DCD (2022), *Indus Towers agrees to Vodafone Idea's softer payment terms on \$850 million debt*, [22]
<https://www.datacenterdynamics.com/en/news/indus-towers-agrees-to-vodafone-ideas-softer-payment-terms-on-850-million-debt/> (accessed on 9 October 2023).
- Dell'Oro (2023), *https://www.delloro.com/news/global-data-center-capex-grew-15-percent-to-241-billion-in-2022/*, [32]
<https://www.delloro.com/news/global-data-center-capex-grew-15-percent-to-241-billion-in-2022/> (accessed on 9 August 2023).
- Developing Telecoms (2023), *Oi Brasil tower sale could net US\$350 million*, [139]
<https://developingtelecoms.com/telecom-business/telecom-investment-mergers/15249-oi-brasil-tower-sale-could-net-us-350-million.html> (accessed on 9 October 2023).
- Dgtl Infra (2023), *Anjana Subsea Cable: Meta Unveils New 4,425-Mile Route*, [67]
<https://dgtlinfra.com/anjana-subsea-cable/> (accessed on 9 August 2023).
- Dgtl Infra (2022), *Apple's Data Center Locations: Enabling Growth in Services*, [56]
<https://dgtlinfra.com/apple-data-center-locations/> (accessed on 9 August 2023).
- Dgtl Infra (2022), *Macquarie, PSP Spend \$610m, Gain Stake in Indonesia's Tower Bersama*, [142]
<https://dgtlinfra.com/macquarie-ppsp-indonesia-tower-bersama/> (accessed on 9 October 2023).
- Diário da República (2022), *Resolution of the Council of Ministers no. 139/2022, of December 28*, [197]
<https://diariodarepublica.pt/dr/detalhe/resolucao-conselho-ministros/139-2022-205378564> (accessed on 8 September 2023).
- Dipartimento per la Trasformazione Digitale (2022), *Banda Ultra Larga*, [101]
<https://innovazione.gov.it/progetti/banda-ultra-larga/> (accessed on 28 August 2023).
- Dish (2021), *Nokia and DISH to Deploy First 5G Standalone Core Network in the Public Cloud with AWS*, [75]
<https://about.dish.com/news-releases?item=123510> (accessed on 9 August 2023).
- DITRDCA (2023), *Better Connectivity Plan for Regional and Rural Australia*, [106]
<https://www.infrastructure.gov.au/media-communications-arts/better-connectivity-plan-regional-and-rural-australia> (accessed on 28 August 2023).
- DOF (2023), *ACUERDO por el que se da a conocer el Programa de Cobertura Social 2022-2023 de la Secretaría de Infraestructura, Comunicaciones y Transportes.*, [112]
https://www.dof.gob.mx/nota_detalle.php?codigo=5677161&fecha=16/01/2023 (accessed on 28 August 2023).

- Ekim (2023), *On-İkinci-Kalkınma-Planı (12th Development Plan)*, [206]
https://onikinciplan.sbb.gov.tr/wp-content/uploads/2023/11/On-İkinci-Kalkınma-Planı_2024-2028.pdf (accessed on 14 December 2023).
- EQT (2023), *EQT Active Core Infrastructure announces first investment to acquire Radius Global Infrastructure*, [21]
<https://eqtgroup.com/news/2023/eqt-active-core-infrastructure-announces-first-investment-to-acquire-radius-global-infrastructure/> (accessed on 9 October 2023).
- EQT (2023), *EQT Infrastructure to acquire a majority stake in Italy's largest mobile network from Wind Tre*, [19]
<https://eqtgroup.com/news/2023/eqt-infrastructure-to-acquire-a-majority-stake-in-italy-s-largest-mobile-network-from-wind-tre/> (accessed on 9 October 2023).
- Espana digital (2022), *UNICO 5G Networks – Fiber Backhaul*, [202]
<https://espanadigital.gob.es/en/lines-action/unico-5g-networks-fiber-backhaul> (accessed on 8 September 2023).
- Espana digital (2021), *UNICO Broadband*, [201]
<https://espanadigital.gob.es/en/measure/unico-broadband> (accessed on 8 September 2023).
- EUR-Lex (2022), *Communication From The Commission Guidelines on State aid for broadband networks 2023/C 36/01*, [110]
<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52023XC0131%2801%29&qid=1675764915102> (accessed on 28 August 2023).
- Eurofondy (2021), *The SFC2021 program supported by the ERDF*, [200]
https://www.eurofondy.gov.sk/wp-content/uploads/2022/11/221115_PSK_Final.pdf (accessed on 8 September 2023).
- European Commission (2023), *Broadband in Austria*, [169]
<https://digital-strategy.ec.europa.eu/en/policies/broadband-austria> (accessed on 8 September 2023).
- European Commission (2023), *Broadband in Sweden*, [204]
<https://digital-strategy.ec.europa.eu/en/policies/broadband-sweden> (accessed on 8 September 2023).
- European Commission (2023), *Daily News 24 / 11 / 2023*, [199]
https://ec.europa.eu/commission/presscorner/detail/en/mex_23_6051 (accessed on 14 December 2023).
- European Commission (2023), *Recovery and Resilience Scoreboard*, [131]
https://ec.europa.eu/economy_finance/recovery-and-resilience-scoreboard/ (accessed on 28 August 2023).
- European Commission (2023), *RECOVERY AND RESILIENCE SCOREBOARD Thematic analysis connectivity*, [100]
https://ec.europa.eu/economy_finance/recovery-and-resilience-scoreboard/assets/thematic_analysis/scoreboard_thematic_analysis_connectivity.pdf (accessed on 28 August 2023).
- European Commission (2022), *Investing in local and regional Gigabit broadband deployment*, [89]
http://file:///C:/Users/Reisch_M/Downloads/A_study_on_investing_in_local_and_regional_Gigabit_broadband_deployment_March_2022_up7vBgMLjXPwuVpfjEBrkOiOms_87440.pdf.
- European Commission (2021), *Global Gateway*, [190]
https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/stronger-europe-world/global-gateway_en (accessed on 30 January 2024).

- European Commission (2021), *NextGenerationEU*, https://commission.europa.eu/strategy-and-policy/eu-budget/eu-borrower-investor-relations/nextgenerationeu_en (accessed on 30 January 2024). [99]
- European Commission (2021), *The Recovery and Resilience Facility*, https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility_en (accessed on 30 January 2024). [189]
- European Commission (2018), *The Connecting Europe Broadband Fund*, <https://digital-strategy.ec.europa.eu/en/library/connecting-europe-broadband-fund> (accessed on 30 January 2024). [187]
- European Commission (2021), *Czechia's recovery and resilience plan*, https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility/czechias-recovery-and-resilience-plan_en (accessed on 8 September 2023). [182]
- FCC (2023), *Universal Service for High Cost Areas - Connect America Fund*, <https://www.fcc.gov/general/universal-service-high-cost-areas-connect-america-fund> (accessed on 8 September 2023). [209]
- Fierce Wireless (2023), *Swisscom takes its time moving to 5G SA with AWS*, <https://www.fiercewireless.com/5g/swisscom-takes-its-time-moving-5g-sa-aws> (accessed on 9 August 2023). [76]
- Financial Review (2023), *Telstra lifts prepaid prices by 20pc; more increases to come*, <https://www.afr.com/companies/telecommunications/telstra-hikes-pre-paid-mobile-prices-by-20pc-more-increases-to-come-20230428-p5d3zz> (accessed on 9 October 2023). [15]
- Financial Review (2022), *Tower sale boom rolls on with \$817m SparkNZ deal*, <https://www.afr.com/companies/telecommunications/tower-sale-boom-rolls-on-with-817m-sparknz-deal-20220712-p5b0xs> (accessed on 9 October 2023). [151]
- Financial Review (2022), *TPG last out the door with \$950m tower sale*, <https://www.afr.com/companies/telecommunications/tpg-last-out-the-door-with-950m-tower-sale-20220509-p5ajms> (accessed on 9 October 2023). [134]
- Forbes (2022), *Philippines' Globe Telecom Sells Cellular Towers For \$340 Million To Macquarie-Backed Consortium*, <https://www.forbes.com/sites/jonathanburgos/2022/09/28/philippines-globe-telecom-sells-cellular-towers-for-340-million-to-macquarie-backed-consortium/?sh=4ff5b66a6598> (accessed on 9 October 2023). [144]
- FPS Economy (2022), *Projectproep "Witte zones"*, <https://economie.fgov.be/nl/nieuws/projectproep-witte-zones> (accessed on 8 September 2023). [170]
- France Stratégie (2023), *Infrastructures numériques et aménagement du territoire*, <https://www.strategie.gouv.fr/sites/strategie.gouv.fr/files/atoms/files/fs-2023-rapport-thd.pdf> (accessed on 8 September 2023). [191]
- Google (2023), *Cloud locations*, <https://cloud.google.com/about/locations> (accessed on 9 August 2023). [47]
- Google (2023), *Discover our data center locations*, <https://www.google.com/about/datacenters/locations/> (accessed on 9 August 2023). [46]

- Google (2023), *https://cloud.google.com/blog/products/infrastructure/new-google-cloud-region-in-turin-italy-now-open?hl=en*, <https://cloud.google.com/blog/products/infrastructure/new-google-cloud-region-in-turin-italy-now-open?hl=en> (accessed on 9 August 2023). [49]
- Google (2023), *Introducing Telecom Data Fabric: Unlock the value of your data*, <https://cloud.google.com/blog/topics/telecommunications/introducing-telecom-data-fabric?hl=en> (accessed on 9 August 2023). [83]
- Google (2023), *Introducing Telecom Network Automation: Unlock 5G cloud-native automation with Google Cloud*, <https://cloud.google.com/blog/topics/telecommunications/introducing-telecom-network-automation?hl=en> (accessed on 9 August 2023). [82]
- Google (2023), *Introducing Telecom Subscriber Insights: Helping CSPs grow business with AI-driven digitization and personalization*, <https://cloud.google.com/blog/topics/telecommunications/introducing-telecom-subscriber-insights?hl=en> (accessed on 9 August 2023). [84]
- Google (2023), *Introduction to GGC*, <https://support.google.com/interconnect/answer/9058809?hl=en> (accessed on 9 August 2023). [60]
- Google (2023), *Leverage Google's decade of experience delivering content*, <https://cloud.google.com/cdn> (accessed on 9 August 2023). [59]
- Google (2023), *Now open, new Doha cloud region set to support Qatar's National Vision 2030*, <https://cloud.google.com/blog/products/infrastructure/new-doha-google-cloud-region-is-now-open?hl=en> (accessed on 9 August 2023). [48]
- Google (2023), *Our Edge Network is how we connect with ISPs to get traffic to and from users*, <https://peering.google.com/#/> (accessed on 9 August 2023). [58]
- Google (2023), *Regions and zones*, <https://cloud.google.com/compute/docs/regions-zones> (accessed on 9 August 2023). [210]
- Google (2022), *Delivering on our \$1 billion commitment in Africa*, <https://blog.google/around-the-globe/google-africa/delivering-on-our-1b-commitment-in-africa/> (accessed on 9 August 2023). [65]
- Google (2022), *The new Google Cloud Region in Israel is now open*, <https://cloud.google.com/blog/products/infrastructure/new-google-cloud-region-in-israel-is-now-open?hl=en> (accessed on 9 August 2023). [50]
- Google (2022), *What's next for Google Fiber*, <https://fiber.google.com/blog/2022/08/whats-next-for-google-fiber.html> (accessed on 9 August 2023). [68]
- gov.pl (2023), *Increasing access to ultra-fast broadband Internet (1 recruitment)*, <https://www.gov.pl/web/cppc/zwiekszenie-dostepu-do-ultra-szybkiego-internetu-szerokopasmowego-1-nabor> (accessed on 8 September 2023). [195]
- gov.pl (2023), *Investment C 1.1.1 Providing access to very fast Internet in white spot areas (first recruitment)*, <https://www.gov.pl/web/cppc/inwestycja-c111-zapewnienie-dostepu-do-bardzo-szybkiego-internetu-na-obszarach-bialych-plam-1-nabor-uruchomiony> (accessed on 8 September 2023). [196]

- GOV.UK (2023), *Project Gigabit progress update, June 2023*, [103]
<https://www.gov.uk/government/publications/project-gigabit-progress-update-june-2023/project-gigabit-progress-update-june-2023> (accessed on 28 August 2023).
- Government of Canada (2022), *First Nation Infrastructure Fund*, [111]
<https://www.sac-isc.gc.ca/eng/1100100010656/1533645154710> (accessed on 28 August 2023).
- Government of Canada (2022), *Investing in Canada Plan funding stream: Rural and Northern Communities infrastructure*, [174]
<https://www.infrastructure.gc.ca/plan/rnc-crn-eng.html> (accessed on 8 September 2023).
- Government of Canada (2022), *Universal Broadband Fund*, [104]
<https://ised-isde.canada.ca/site/high-speed-internet-canada/en/universal-broadband-fund> (accessed on 28 August 2023).
- Government of Canada (2021), *Connect to Innovate*, [171]
<https://ised-isde.canada.ca/site/connect-to-innovate/en> (accessed on 8 September 2023).
- Government of Canada (2021), *Universal Broadband Fund and Telesat low Earth orbit capacity agreement*, [132]
<https://www.canada.ca/en/innovation-science-economic-development/news/2020/11/universal-broadband-fund-and-telesat-low-earth-orbit-capacity-agreement.html> (accessed on 28 August 2023).
- Government of Canada (2020), *2014: The 2014 New Building Canada Fund: Provincial-Territorial Infrastructure Component Small Communities Fund*, [176]
<https://www.infrastructure.gc.ca/plan/sc-cp-eng.html>.
- Government of Canada (2020), *Connecting Canadians*, [172]
<https://www.canada.ca/en/innovation-science-economic-development/news/2016/04/connecting-canadians.html> (accessed on 8 September 2023).
- Government of Iceland (2020), *Iceland's Rural Fibre Project*, [192]
<https://www.government.is/topics/transport-and-telecommunications/icelands-rural-fibre-project/> (accessed on 8 September 2023).
- Government of Ireland (2020), *National Broadband Plan*, [193]
<https://www.gov.ie/en/publication/c1b0c9-national-broadband-plan/> (accessed on 8 September 2023).
- HaDEA (2021), *Connecting Europe Facility – Digital*, [188]
https://hadea.ec.europa.eu/programmes/connecting-europe-facility_en (accessed on 30 January 2024).
- HGM (2017), *Ulusal Genişbant Stratejisi (National Broadband Strategy)*, [205]
<https://hgm.uab.gov.tr/ulusal-genisbant-stratejisi> (accessed on 14 December 2023).
- Iliad (2023), *Completion of the sale of the 30% stake in On Tower Poland*, [154]
<https://www.globenewswire.com/news-release/2023/06/30/2697933/0/en/Iliad-press-release-Completion-of-the-sale-of-the-30-stake-in-On-Tower-Poland.html> (accessed on 9 October 2023).
- IMF et al. (2022), *Subsidies, Trade, and International Cooperation*, [98]
<https://doi.org/10.1787/a4f01ddb-en> (accessed on 27 September 2023).

- Inside Towers (2021), *Canadian Towers Attract U.S. Interest*, <https://insidetowers.com/cell-tower-news-canadian-towers-attract-u-s-interest/> (accessed on 9 October 2023). [11]
- Internet for All (2023), *BROADBAND EQUITY, ACCESS, AND DEPLOYMENT (BEAD) PROGRAM*, <https://internetforall.gov/program/broadband-equity-access-and-deployment-bead-program> (accessed on 28 August 2023). [117]
- investingnews (2023), <https://investingnews.com/daily/tech-investing/top-technology-stocks/>, <https://investingnews.com/daily/tech-investing/top-technology-stocks/> (accessed on 17 May 2023). [30]
- ITF (2022), *Comunicado de Prensa No.060/2022*, <https://www.ift.org.mx/sites/default/files/comunicacion-y-medios/comunicados-ift/comunicado60ift1.pdf> (accessed on 26 February 2024). [18]
- JPMorgan Chase & Co (2009), *Infrastructure Investing: Key Risks and Benefits*, <https://www.ceresaiq.com/wp-content/uploads/2017/08/Infrastructure-Investing-Key-Benefits-and-Risks-JPM.pdf>. [91]
- Light Reading (2022), *Australia's NBN gets another \$1.5B to build out full fiber*, [https://www.lightreading.com/broadband/fttx/australias-nbn-gets-another-\\$15b-to-build-out-full-fiber/d/d-id/781219](https://www.lightreading.com/broadband/fttx/australias-nbn-gets-another-$15b-to-build-out-full-fiber/d/d-id/781219) (accessed on 8 September 2023). [166]
- Light Reading (2022), *How Europe's biggest telcos lost control of their towers*, <https://www.lightreading.com/5g/how-europe-s-biggest-telcos-lost-control-of-their-towers#close-modal> (accessed on 9 October 2023). [140]
- Lipscombe, P. (2023), *Italian government strikes preliminary deal with KKR to take up 20% stake in Telecom Italia's landline grid*, <https://www.datacenterdynamics.com/en/news/italian-govt-strikes-preliminary-deal-with-kr-to-take-up-to-20-stake-in-telecom-italias-landline-grid/>. [93]
- Livewire (2022), *Communication towers: Why are they so exciting?*, <https://www.livewiremarkets.com/wires/communication-towers-why-are-they-so-exciting> (accessed on 9 October 2023). [137]
- Macquarie (2023), *Creating Australia's largest standalone wireless tower company*, <https://www.macquarie.com/au/en/impact/case-studies/creating-australias-largest-standalone-wireless-tower-company.html> (accessed on 9 October 2023). [135]
- Macquarie (2022), *Macquarie Asset Management announces sale of Axicom to Australia Tower Network*, <https://www.macquarie.com/au/en/about/news/2022/macquarie-asset-management-announces-sale-of-axicom-to-australia-tower-network.html> (accessed on 9 October 2023). [136]
- Macquarie (2022), *Towers of opportunity: Asia's investors eye the fundamentals*, <https://www.macquarie.com/au/en/insights/towers-of-opportunity-asias-investors-eye-the-fundamentals.html> (accessed on 9 October 2023). [143]
- MBNL (2023), *OUR SHAREHOLDERS*, <https://mbnl.co.uk/our-shareholders/> (accessed on 9 October 2023). [7]

- McKinsey & Company (2020), *How COVID-19 has pushed companies over the technology tipping point—and transformed business forever*, <https://www.mckinsey.com/capabilities/strategy-and-corporate-finance/our-insights/how-covid-19-has-pushed-companies-over-the-technology-tipping-point-and-transformed-business-forever> (accessed on 19 October 2022). [90]
- Meta (2023), *Meta's global data center fleet*, <https://datacenters.atmeta.com/all-locations/> (accessed on 9 August 2023). [55]
- Meta (2020), *Facebook Connectivity Investments to Deliver Over \$200 Billion in Economic Benefits*, <https://about.fb.com/news/2020/07/facebook-connectivity-economic-benefits/> (accessed on 29 September 2023). [69]
- MIC (2023), *JICT*, https://www.soumu.go.jp/menu_seisaku/ictseisaku/jict/index.html (accessed on 28 August 2023). [126]
- MIC (2023), *Project to Promote Advanced Wireless Environment*, <https://www.tele.soumu.go.jp/j/sys/fees/purpose/koudo/index.htm>. [118]
- Microsoft (2023), *Azure for operators*, <https://azure.microsoft.com/en-us/solutions/telecommunications#overview> (accessed on 13 December 2023). [78]
- Microsoft (2023), *Azure global infrastructure*, <https://azure.microsoft.com/en-us/explore/global-infrastructure> (accessed on 9 August 2023). [51]
- Microsoft (2023), *Azure Operator Nexus*, <https://azure.microsoft.com/en-us/products/operator-nexus> (accessed on 9 August 2023). [80]
- Microsoft (2023), *Microsoft announces A\$5 billion investment in computing capacity and capability to help Australia seize the AI era*, <https://news.microsoft.com/en-au/features/microsoft-announces-a5-billion-investment-in-computing-capacity-and-capability-to-help-australia-seize-the-ai-era/#:~:text=Microsoft%20will%20invest%20A%245,year%20history%20in%20the%20country> (accessed on 13 December 2023). [54]
- Microsoft (2023), *Microsoft global network*, <https://learn.microsoft.com/en-us/azure/networking/microsoft-global-network> (accessed on 9 August 2023). [61]
- Microsoft (2023), *What are availability zones?*, <https://learn.microsoft.com/en-us/azure/reliability/availability-zones-overview?tabs=azure-cli> (accessed on 9 October 2023). [213]
- Microsoft (2022), *AT&T to run its mobility network on Microsoft's Azure for Operators cloud, delivering cost-efficient 5G services at scale*, <https://news.microsoft.com/2021/06/30/att-to-run-its-mobility-network-on-microsofts-azure-for-operators-cloud-delivering-cost-efficient-5g-services-at-scale/> (accessed on 27 October 2022). [79]
- Microsoft (2022), *Microsoft and Viasat Announce New Partnership to Deliver Internet Access to Underserved Communities Globally*, <https://news.microsoft.com/en-xm/2022/12/15/microsoft-and-viasat-announce-new-partnership-to-deliver-internet-access-to-underserved-communities-globally/> (accessed on 9 August 2023). [73]

- Microsoft (2022), *Microsoft responds to European Cloud Provider feedback with new programs and principles*, <https://blogs.microsoft.com/eupolicy/2022/05/18/microsoft-responds-to-european-cloud-provider-feedback-with-new-programs-and-principles/> (accessed on 13 December 2023). [53]
- Microsoft (2021), *Advancing reliability through a resilient cloud supply chain*, <https://azure.microsoft.com/en-us/blog/advancing-reliability-through-a-resilient-cloud-supply-chain/> (accessed on 9 August 2023). [52]
- MIG (2021), *Lückenlosen Mobilfunk fördern: Die Mobilfunkinfrastrukturgesellschaft (MIG) geht an den Start*, <https://netzda-mig.de/aktuelles/details/lueckenlosen-mobilfunk-foerdern-die-mobilfunkinfrastrukturgesellschaft-mig-geht-an-den-start> (accessed on 28 August 2023). [121]
- Ministerio de Asuntos Económicos y Transformación Digital (2020), *The Government presents the Plan for Connectivity and Digital Infrastructure and the Strategy to Promote 5G Technology, endowed with 4,320 million euros until 2025*, https://portal.mineco.gob.es/en-us/comunicacion/Pages/201201_np_conectividad.aspx (accessed on 8 September 2023). [203]
- Ministry of Business, Innovation & Employment (2022), *Lifting Connectivity in Aotearoa New Zealand*, <https://www.mbie.govt.nz/assets/lifting-connectivity-in-aotearoa-new-zealand-december-22.pdf> (accessed on 8 September 2023). [194]
- Ministry of Digital Governance (2023), *Υπογραφή Σύμβασης Σύμπραξης για το έργο «Ultra – Fast Broadband»*, <https://mindigital.gr/archives/5185> (accessed on 28 August 2023). [125]
- Ministry of Economy and Finance of Korea (2020), *Government releases an English Booklet of the New Deal*, <https://english.moef.go.kr/pc/selectTbPressCenterDtl.do?boardCd=N0001&seq=4948>. [114]
- Ministry of Industry and Trade (2015), *OP PIK is the first Czech program for the period 2014 - 2020 approved by the European Commission*, <https://www.mpo.cz/en/guidepost/for-the-media/press-releases/op-pik-is-the-first-czech-program-for-the-period-2014---2020-approved-by-the-european-commission--157800/> (accessed on 8 September 2023). [181]
- Mobile World Live (2022), *Docomo offloads towers to JTower for \$870M*, <https://www.mobileworldlive.com/featured-content/top-three/docomo-offloads-towers-to-jtower-for-870m/> (accessed on 9 October 2023). [146]
- Mobile World Live (2022), *Orange Totem unit secures Iliad tower deal*, <https://www.mobileworldlive.com/featured-content/top-three/orange-totem-unit-secures-iliad-tower-deal/> (accessed on 9 October 2023). [9]
- Moonfare (2022), *Private Equity Infrastructure Funds*, https://assets-global.website-files.com/5ffb7d86352880856dbd363e/62bbfd66e02d27c13b09b720_20220614_Infra_Phase_1.pdf. [85]
- Nareit (2021), *What's a REIT (Real Estate Investment Trust)?*, <https://www.reit.com/what-reit> (accessed on 9 October 2023). [26]
- New Zealand Government (2022), *Crown Infrastructure Partners Limited*, <https://www.treasury.govt.nz/information-and-services/commercial-portfolio-and-advice/commercial-portfolio/crown-infrastructure-partners-limited> (accessed on 28 August 2023). [122]

- Nkom (2023), *Offentlig støtte til bredbåndsutbygging*, <https://nkom.no/fysiske-nett-og-infrastruktur/offentlig-stotte-til-bredbåndsutbygging> (accessed on 28 August 2023). [105]
- NTIA (2023), *Tribal Broadband Connectivity Program*, <https://broadbandusa.ntia.doc.gov/funding-programs/tribal-broadband-connectivity> (accessed on 28 August 2023). [113]
- OECD (2024), *Broadband Portal*, <https://www.oecd.org/digital/broadband/broadband-statistics/> (accessed on 5 March 2024). [2]
- OECD (2023), *Enhancing Rural Innovation in the United States*, OECD Rural Studies, OECD Publishing, Paris, <https://doi.org/10.1787/22a8261b-en>. [3]
- OECD (2023), *Public procurement*, <https://www.oecd.org/gov/public-procurement/> (accessed on 28 September 2023). [116]
- OECD (2022), “*Developments in spectrum management for communication services*”, *OECD Digital Economy Papers*, No. 332, OECD Publishing, Paris, <https://doi.org/10.1787/175e7ce5-en> (accessed on 13 December 2023). [215]
- OECD (2022), *Broadband networks of the future*, <https://doi.org/10.1787/755e2d0c-en> (accessed on 9 August 2023). [31]
- OECD (2021), “*Bridging connectivity divides*”, *OECD Digital Economy Papers*, No. 315, OECD Publishing, Paris, <https://doi.org/10.1787/e38f5db7-en>. [5]
- OECD (2021), *Bridging digital divides in G20 countries*, OECD Publishing, Paris, <https://doi.org/10.1787/35c1d850-en>. [127]
- OECD (2021), *Recommendation of the Council on Broadband Connectivity*, *OECD/LEGAL/0322*, Compendium of Legal Instruments, <https://legalinstruments.oecd.org/en/instruments/OECD-LEGAL-0322>. [214]
- OECD (2019), “*The operators and their future: The state of play and emerging business models*”, *OECD Digital Economy Papers*, No. 287, OECD Publishing, Paris, <https://doi.org/10.1787/60c93aa7-en>. [1]
- OECD (2015), “*Development of High-speed Networks and the Role of Municipal Networks*”, *OECD Science, Technology and Industry Policy Papers*, No. 26, OECD Publishing, Paris, <https://doi.org/10.1787/5jrqli7rvns3-en>. [128]
- OECD (2012), *OECD Recommendation on Principles for Public Governance of Public-Private Partnerships*, <https://www.oecd.org/gov/oecd-recommendation-public-privatepartnerships.htm> (accessed on 28 August 2023). [211]
- OECD/IDB (2016), *Broadband Policies for Latin America and the Caribbean: A Digital Economy Toolkit*, <https://doi.org/10.1787/9789264251823-en> (accessed on 28 August 2023). [119]
- Office of the Auditor General of Canada (2023), *Connectivity in rural and remote areas*, https://www.oag-bvg.gc.ca/internet/English/att_e_44225.html (accessed on 8 September 2023). [173]

- Omdia (2022), *Cloud-Native Networks are the Future of the Telecom Industry*, [81]
<https://cloud.google.com/resources/cloud-native-networks-are-the-future-of-the-telecom-industry> (accessed on 9 August 2023).
- Orange (2023), *TOTEM, the Orange TowerCo subsidiary, deploys a next-generation 5G network at the Orange Vélodrome*, [10]
<https://newsroom.orange.com/totem-the-orange-towerco-subsidiary-deploys-a-next-generation-5g-network-at-the-orange-velodrome/> (accessed on 9 October 2023).
- Plačiajuostis internetas (2023), *Plačiajuostis internetas*, [123]
<https://www.placiajuostis.lt/> (accessed on 28 August 2023).
- Planet 4589 (2023), *Jonathan's Space Pages*, [71]
<https://planet4589.org/space/con/star/stats.html> (accessed on 9 October 2023).
- Preqin (2020), *Global Infrastructure Report*, [86]
<https://www.preqin.com/insights/global-reports/2020-preqin-global-infrastructure-report>.
- Radius Global Infrastructure (2023), *Radius Global Infrastructure Reports Second Quarter 2023 Results*, [164]
<https://www.radiusglobal.com/news-releases/news-release-details/radius-global-infrastructure-reports-second-quarter-2023-results> (accessed on 9 October 2023).
- RCR Wireless (2021), *Verizon dominated the C Band auction, spending \$45.45 billion for 3,500 licenses*, [94]
<https://www.rcrwireless.com/20210225/carriers/verizon-dominated-the-c-band-auction> (accessed on 20 October 2022).
- RCR Wireless News (2021), *Rakuten acquires JTower stake to reduce network rollout costs*, [147]
<https://www.rcrwireless.com/20211018/business/rakuten-acquires-jtower-stake-reduce-network-rollout-costs> (accessed on 9 October 2023).
- Reuters (2023), *Reliance Jio's new low-cost phone unlikely to disrupt Indian telecom market, analysts say*, [24]
<https://www.reuters.com/business/media-telecom/indian-telecom-stocks-take-hit-after-jio-taps-rural-market-with-12-4g-phone-2023-07-04/> (accessed on 9 October 2023).
- Riigi Tugiteenuste Keskus (2023), *Construction of a very high capacity electronic communications access network (RRF)*, [185]
<https://www.rtk.ee/lairiba> (accessed on 8 September 2023).
- RNZ (2022), *Vodafone agrees to \$1.7b sale of mobile phone towers*, [153]
<https://www.rnz.co.nz/news/business/471133/vodafone-agrees-to-1-point-7b-sale-of-mobile-phone-towers> (accessed on 9 October 2023).
- Rowland, M. (2022), *First major milestone delivered under the Better Connectivity for Rural and Regional Australia Plan*, [167]
https://minister.infrastructure.gov.au/rowland/media-release/first-major-milestone-delivered-under-better-connectivity-rural-and-regional-australia-plan?utm_source=miragenews&utm_medium=miragenews&utm_campaign=news#:~:text=The%20Australian%20Government%20 (accessed on 8 September 2023).
- S&P Global (2021), *Long-term demand for communication tools pulls PE capital into sector*, [87]
<https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/long-term-demand-for-communication-tools-pulls-pe-capital-into-sector-62785434> (accessed on 18 October 2022).

- Semanario Universidad (2021), *Sutel ha conectado a Internet menos del 10% de los centros educativos bajo la Red Educativa del Bicentenario*, <https://semanariouniversidad.com/pais/sutel-ha-conectado-a-internet-menos-del-10-de-los-centros-educativos-bajo-la-red-educativa-del-bicentenario/> (accessed on 8 September 2023). [180]
- Shared Rural Network (2020), *The Shared Rural Network is bringing mobile broadband to rural communities across the UK*, <https://srn.org.uk/> (accessed on 8 September 2023). [208]
- Subsecretaría de Telecomunicaciones (2023), *Fondo de Desarrollo de Telecomunicaciones*, <https://www.subtel.gob.cl/quienes-somos/divisiones-2/fondo-de-desarrollo-de-las-telecomunicaciones/> (accessed on 28 August 2023). [107]
- Subtel (2023), *Memoria FDT 2021-2022*, <https://www.subtel.gob.cl/memoria-fdt-2021-2022/> (accessed on 8 September 2023). [178]
- Synergy Research Group (2023), *Q1 Cloud Spending Grows by Over \$10 Billion from 2022; the Big Three Account for 65% of the Total*, <https://www.srgresearch.com/articles/q1-cloud-spending-grows-by-over-10-billion-from-2022-the-big-three-account-for-65-of-the-total> (accessed on 9 August 2023). [33]
- TechCrunch (2021), *Google confirms \$1B investment into Africa, including subsea cable for faster internet*, <https://techcrunch.com/2021/10/06/google-confirms-1b-investment-into-africa-including-subsea-cable-for-faster-internet/> (accessed on 9 August 2023). [66]
- Telco Titans (2023), *BT and Three go “unilateral” in MBNL refocus*, <https://www.telcotitans.com/btwatch/bt-and-three-go-unilateral-in-mbni-refocus/6406.article> (accessed on 9 October 2023). [8]
- Telefónica (2021), *Telefonica sells Telxius tower division to American Towers Corporation at record multiples for 7.7 billion euros*, <https://www.telefonica.com/en/communication-room/press-room/telefonica-sells-telxius-tower-division-to-american-towers-corporation-at-record-multiples-for-7-7-billion-euros/> (accessed on 9 October 2023). [138]
- TeleGeography (2023), *A Complete List of Content Providers’ Submarine Cable Holdings*, <https://blog.telegeography.com/telegeographys-content-providers-submarine-cable-holdings-list> (accessed on 9 August 2023). [64]
- TeleGeography (2023), *Submarine Cable Map*, <https://www.submarinemap.com/> (accessed on 9 August 2023). [165]
- TeleGeography (2022), *America Movil confirms listing of Sitios Latinoamerica shares*, <https://www.commsupdate.com/articles/2022/09/30/america-movil-confirms-listing-of-sitios-latinoamerica-shares/> (accessed on 9 October 2023). [149]
- TeleGeography (2022), *Content Providers Binge on Global Bandwidth*, <https://blog.telegeography.com/content-providers-binge-on-global-bandwidth> (accessed on 8 August 2023). [63]
- TeleGeography (2021), *All About That \$8 Billion in Subsea Cable Investment*, <https://blog.telegeography.com/telecom-headlines-june-2021> (accessed on 9 August 2023). [62]
- TeleGeography (202), *TIM prepares to close INWIT stake sale*, <https://www.commsupdate.com/articles/2022/08/02/tim-prepares-to-close-inwit-stake-sale/> (accessed on 9 October 2023). [145]

- Telesat (2020), *Telesat and the Government of Canada Finalize \$600M Agreement to Bridge Canada's Digital Divide with Telesat's Low Earth Orbit Satellite Constellation*, <https://www.telesat.com/press/press-releases/telesat-and-the-government-of-canada-finalize-600m-agreement-to-bridge-canadas-digital-divide-with-telesats-low-earth-orbit-satellite-constellation/> (accessed on 8 September 2023). [175]
- Telia Company (2022), *Telia Company completes the sale of a minority stake in its Swedish tower business to Brookfield and Alecta*, <https://www.teliacompany.com/en/press-releases/FB062772181B1E3C> (accessed on 9 October 2023). [157]
- The Danish Agency for Data Supply and Infrastructure (2022), *Internet Baggrundsark*, <https://sdfi.dk/Media/638067768708985947/Internet%20Baggrundsark%201H22.xlsx> (accessed on 8 September 2023). [130]
- The Department of Infrastructure, Transport, Regional Development, Communications and the Arts (2022), *Better Connectivity Plan for Regional and Rural Australia*, <https://www.infrastructure.gov.au/media-communications-arts/better-connectivity-plan-regional-and-rural-australia> (accessed on 8 September 2023). [168]
- The Guardian (2023), *Judge blocks Telstra and TPG deal to share regional mobile networks*, <https://www.theguardian.com/australia-news/2023/jun/21/judge-blocks-telstra-and-tpg-deal-to-share-regional-mobile-networks> (accessed on 9 October 2023). [17]
- The Ministry of Education, Science, and Sport (2016), *THE NEXTGENERATION BROADBAND NETWORK DEVELOPMENT PLAN TO 2020*, https://www.gov.si/assets/ministrstva/MDP/DID/NGN_2020_Slovenia_EN.pdf (accessed on 28 August 2023). [124]
- The Telegraph (2020), *Seal on RIL tower plan*, <https://www.telegraphindia.com/business/seal-on-ril-tower-plan/cid/1790695> (accessed on 9 October 2023). [141]
- TRAFICOM (2022), *Broadband aid has accelerated the availability of high-speed connections in Finland – nearly 30,000 kilometres of optical fibre, EUR 60 million of state aid*, <https://www.traficom.fi/en/news/broadband-aid-has-accelerated-availability-high-speed-connections-finland-nearly-30000> (accessed on 28 August 2023). [108]
- Two Degrees Mobile (2023), *Connexa completes acquisition of 2degrees' passive mobile tower assets*, <https://www.2degrees.nz/media-releases/connexa-complete-aquisition-of-2degrees-tower-assets> (accessed on 9 October 2023). [152]
- V.tal (2023), *About us*, <https://www.vtal.com/en/about-us/> (accessed on 6 October 2023). [97]
- Vodafone (2022), *Vodafone enters into a co-control partnership with GIP and KKR for Vantage Towers*, <https://www.vodafone.com/news/corporate-and-financial/vodafone-enters-co-control-partnership-gip-and-krk-vantage-towers> (accessed on 9 October 2023). [158]
- Wiggins, J. (2023), *UniSuper snares USD 1 Billion stake in Europe's Vantage Towers*, <https://www.afr.com/companies/infrastructure/unisuper-snares-1b-stake-in-europe-s-vantage-towers-20230504-p5d5ks>. [92]
- Worldbank (2023), *DataBank*, <https://databank.worldbank.org/home.aspx> (accessed on 10 October 2023). [4]

- Yahoo (2023), *Wiable Corp. (065530.KQ)*, [148]
https://finance.yahoo.com/quote/065530.KQ/profile/?guce_referrer=aHR0cHM6Ly93d3cuZ29vZ2xlMnVbS8&guce_referrer_sig=AQAAAMBwa06zQVgVp5_dNsNham1YPglquw9ceGSXa qPFdaWNYzTF8mSk1Xwxny0LxigFUx07ZePnZGa-rywWDMcZCZlqA0oGH8w7p_zv-3cwBpXGW1yEwAl4gj07hd1eBsB2OG8cFrtW (accessed on 9 October 2023).
- Ελλάδα 2.0 (2023), *Πρόγραμμα “Smart Readiness” - Ετοιμότητα υποδομών για έξυπνα κτίρια*, [115]
<https://greece20.gov.gr/?calls=smart-readiness-etoimotita-ypodomon-gia-exyprna-ktiria> (accessed on 28 August 2023).

End notes

¹ Using daily conversion rates as provided by Bloomberg.

² This analysis of revenues is based on the Bloomberg dataset, which includes 195 listed companies see Annex 1.A).

³ For the analysis, GSMA data only includes OECD countries. These are split up regionally as follows:

- Asia Pacific: Australia, Japan, Korea, New Zealand.
- Europe: Austria, Belgium, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye, United Kingdom.
- United States and Canada: United States, Canada.
- Latin America: Chile, Colombia, Costa Rica, Mexico.

⁴ These revenues do not include data of content providers, such as marketing revenues.

⁵ *Indexed CAPEX year*_t = $\frac{CAPEX_t - CAPEX_{t-k}}{CAPEX_{t-k}}$, where *k* is the base year.

⁶ Svenska UMTS-Nät AB jointly owned by Tele2 and Telia; and 3G Infrastructure Services Aktiebolag jointly owned by Telenor and Hi3G (3).

⁷ An exchange rate of 0.950 EUR/USD for the year 2022 from OECD.stat has been used.

⁸ In their report, Analysys Mason analyses “content and application providers” (CAPs). CAPs include content delivery networks (CDNs) and cloud providers, which invest in and operate data centres, peering and caching infrastructure. The investment by CAPs is estimated in three separate clusters of infrastructure: hosting (data centres and cloud), transport (cables transporting content), and delivery (peering and caching).

⁹ A region is a specific and separate geographical location where users can host their resources. Regions are a collection of separate zones (AWS, 2023^[212]) (Google, 2023^[210]) (Microsoft, 2023^[213])

¹⁰ An exchange rate of 1.442 ASD/USD for the year 2022 from OECD.stat has been used.

¹¹ An exchange rate of 1.379 SGD/USD for the year 2022 from OECD.stat has been used.

¹² An exchange rate of 7.076 DKK/USD for the year 2022 from OECD.stat has been used.

¹³ An exchange rate of 0.950 EUR/USD for the year 2022 from OECD.stat has been used.

¹⁴ An exchange rate of 10.114 SEK/USD for the year 2022 from OECD.stat has been used.

¹⁵ “Owned solely” and “jointly owned” is judged from the “Owners” section in the TeleGeography’s Submarine Cable Map. It is possible that there are small or individual owners not listed on the Submarine Cable Map.

¹⁶ An exchange rate of 0.845 EUR/USD for the year 2021 from OECD.stat has been used.

¹⁷ An exchange rate of 0.950 EUR/USD for the year 2022 from OECD.stat has been used.

¹⁸ An exchange rate of 0.845 EUR/USD for the year 2021 from OECD.stat has been used.

¹⁹ An exchange rate of 1.414 NZD/USD for the year 2021 from OECD.stat has been used.

²⁰ An exchange rate of 0.780 GBP/USD for the year 2020 from OECD.stat has been used.

²¹ An exchange rate of 1.327, 1.341 and 1.302 CAD/USD for the year 2019, 2020 and 2022 from OECD.stat has been used, respectively.

²² An exchange rate of 8.590 NOK/USD for the year 2021 from OECD.stat has been used.

²³ An exchange rate of 1.442 ASD/USD for the year 2022 from OECD.stat has been used.

²⁴ An exchange rate of 0.950 EUR/USD for the year 2022 from OECD.stat has been used.

²⁵ An exchange rate of 0.845 EUR/USD for the year 2021 from OECD.stat has been used.

²⁶ The OECD has established principles for public governance of public-private partnerships to assist with good practices in this area. When implementing PPP for broadband deployment, it is necessary to note to the following points. (a) Establish a clear, predictable and legitimate institutional framework supported by competent and well-resourced authorities, (b) Ground the selection of Public-Private Partnerships in value for money, and (c) Use the budgetary process transparently to minimise fiscal risks and ensure the integrity of the procurement process (OECD, 2012^[211]).

²⁷ An exchange rate of 0.950 EUR/USD for the year 2022 from OECD.stat has been used.

²⁸ An exchange rate of 131.498 JPY/USD for the year 2022 from OECD.stat has been used.

²⁹ An exchange rate of 7.076 DKK/USD for the year 2022 from OECD.stat has been used.

³⁰ An exchange rate of 0.950 EUR/USD for the year 2022 from OECD.stat has been used.

³¹ An exchange rate of 1.254 CAD/USD for the year 2021 from OECD.stat has been used.

³² Please see also: *OECD Recommendation of the Council on Broadband Connectivity* (OECD, 2021^[214]); *G20 Guidelines for Financing and Fostering High-Quality Broadband Connectivity for a Digital World, developed with the support of the OECD*; *Broadband networks of the future* (OECD, 2022^[31]); and *Developments in spectrum management for communication services* (OECD, 2022^[215]).

³³ As defined by the market capitalisation criterium for the section on big publicly listed technology companies in this report, this table lists submarine fibre holdings if owned by Google (Alphabet), Microsoft, Meta, Amazon, or Apple.