Bridging digital divides in G20 countries

OECD Report for the G20 Infrastructure Working Group

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Introduction

1. Reliable connectivity is fundamental for the digital transformation as it is the invisible thread across all sectors of the economy. The COVID-19 health emergency has further accentuated the awareness among policy makers on how the resilience and capability of broadband networks are becoming even more critical. As economies adapt to a model of more generalised remote work and delivery of public services through broadband connectivity, places and individuals that suffer from digital divides are less prepared for the transition (OECD, 2021[1]). As such, the health emergency and confinement measures that have led to remote schooling and teleworking have been a “turning point” in the push for ubiquitous connectivity in many countries, with businesses, society and policy makers realising the urgency to act.

2. On many dimensions, great progress has been made to increase the number of connected people and on closing divides around the world, across and within territories. However as the digital transformation takes hold, one of the most challenging questions is how to accompany countries to ensure that everyone benefits and nobody is left behind, regardless of where they live.

3. Previous G20 agreements have already recognised the goal of promoting universal and affordable access to the Internet by all people by 2025. The G20 Digital Economy Declaration of 2017 mentioned: “The *G20 countries recognise that digital infrastructure is fundamental to digitalisation, yet not everyone has the same opportunities to connect for access. Digital divides persist across income, age, geography, and gender. Therefore, we reaffirm our commitment made in Hangzhou to the Connect 2020 Agenda’s goal of connecting the next 1.5 billion people by 2020 and will encourage the domestic deployment of connectivity to all people by 2025, in accordance with the respective nation’s strategic and developmental policy frameworks. With regard to improving connectivity infrastructure, we welcome policy and regulation that promote competitive environment in order to encourage private sector investment*” (G20, 2017[2]).

4. This synthesis report measures spatial divides between urban and rural areas. It also identifies a number of policy recommendations that can help close existing spatial digital divides in G20 countries.

5. The term “digital divide” is a broad concept commonly used to refer to different levels of access and use of information and communication technologies (ICTs) and, more specifically, to the gaps in access and use of Internet-based digital services. Broadband access, as a general-purpose technology, provides the physical means for using these services (OECD, 2018[3]).

6. Digital divides vary across territories and may be driven by a myriad of factors including: territorial characteristics such as density, demography and distance to cities; socio-economic factors such as gender, age, skill level; and firm characteristics such as firm size. Some determinants of digital divides are commonly attributed to territorial characteristics and others are often accentuated by them, such as those in income and skill disparities.

7. The definition of “gap” or “divide” inherently means a comparison within and between groups; therefore, there is an implicit reference group in mind when assessing divides (e.g. non-metropolitan regions versus metropolitan regions, small and medium enterprises [SMEs] versus large firms, developed versus emerging economies, etc.).

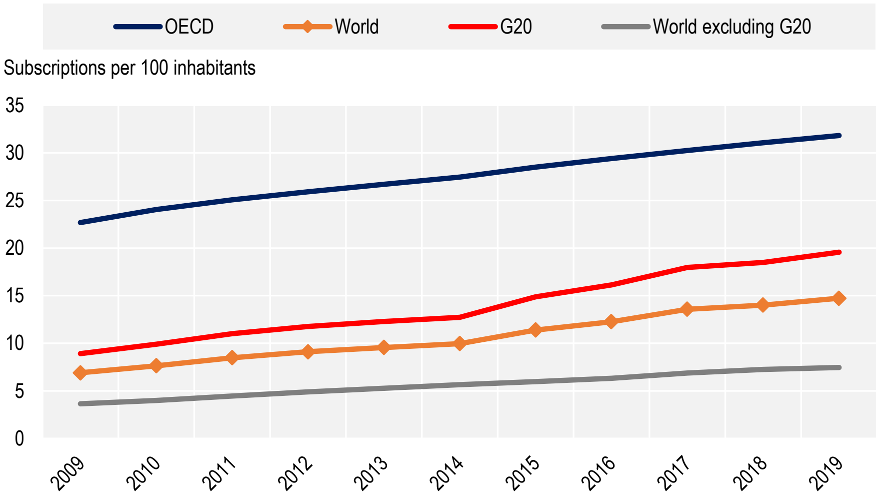
8. Digital divides can occur across a variety of dimensions. A useful way to conceptualise the issue is in terms of three different layers, all three of which need to be addressed in a co-ordinated way to achieve ubiquitous and equitable access for all:

- the network or connectivity layer (i.e. access and uptake of communication services),
- the application interfaces and data layer (i.e. access and transfer of data across borders; applications running on networks), and

- the end-user layer (i.e. the diffusion of digital technologies and how these are employed, taking into account the heterogeneity of firms and individuals).

9. A first type of divide exists *between* countries. Looking at broadband access, for example, while overall levels of broadband subscriptions are increasing throughout the world, the levels of broadband subscriptions are higher among G20 countries. The latter countries had, on average, 19.6 fixed broadband subscriptions per 100 inhabitants in 2019, which was 2.6 times the rate in the rest of the world(7.5 subscriptions per 100) (Figure 1).

Figure 1. Fixed broadband evolution, G20 countries, OECD and world



Source: OECD (2021[4]), *Broadband Portal* (database), www.oecd.org/sti/broadband/oecdbroadbandportal.htm (accessed 25 February 2021), and ITU (2021[5]), *World Telecommunication/ICT Indicators* (database), www.itu.int/pub/D-IND-WTID.OL (accessed 25 February 2021).

10. The “connectivity divide” is a common occurrence in areas with low population densities and disadvantaged groups. To bridge it, people not only need to have an Internet connection, but their connection needs to be affordable and of high quality. Ensuring high-quality connectivity for all places and people will become even more important as activities, such as work and education, and even health, are increasingly conducted in a remote manner. One important parameter of the performance of broadband connections is speed. Teleworking and online education applications, for instance, require both good upload download speeds.

11. Bridging the connectivity divide is by no means an issue solely concerning rural and remote regions. However, these regions generally have a unique set of issues associated with their low density and distance to core network facilities (OECD, 2018[3]). Assisting rural and remote communities to bridge broadband access and uptake gaps is critical to strengthening their overall economic and social development.

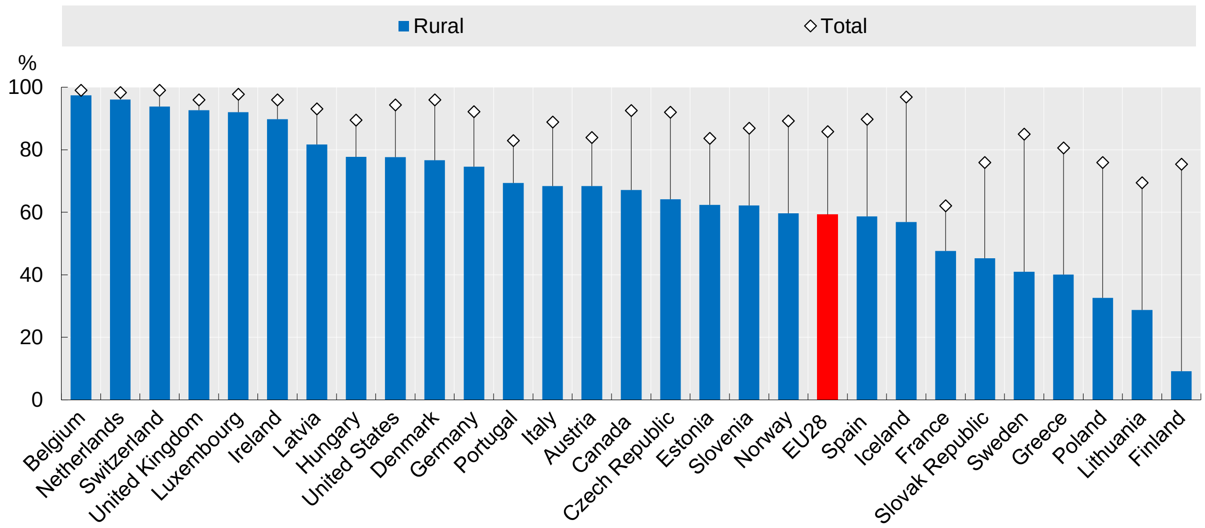
Assessing existing digital divides between urban and rural areas in the G20

12. In addition to the digital divide between countries, a second type of divide exists *within* countries. Addressing these divides through spatially-sensitive national and regional policies is necessary to ensure that existing gaps in communication infrastructure and digital human capital are not further magnified, leaving some places with little chance to catch-up with their more advanced peers.

13. Substantial disparities in connectivity persist between urban and rural areas in the quality of broadband connections (for territorial definitions please see Box 2). Looking at the availability of fixed broadband services in terms of geographical coverage with a minimum speed of 30 Mbps reveals significant gaps between rural and urban households. For example, in 2019, only 59% of rural households in Europe were located in regions where access to fixed broadband with a minimum speed of 30 Mbps was available, in comparison to 86% of households in all areas overall. In Canada, 93% of overall households had such availability in 2019, but that share was only 67% in rural areas. At the end of 2018, in the United States,[1] the availability was 77.7% in rural areas, against 94.4% in total (Figure 2).

Figure 2. Households in areas where fixed broadband with a contracted speed of 30 Mbps or more is available, total and rural, 2019*

As a percentage of households in each category



Note: *For the United States, coverage of fixed terrestrial broadband capable of delivering 25 Mbps download and 3 Mbps upload services was used; data in the United States refer to end of 2018, and they use a population coverage approach rather than percentage of households covered. *Rural areas*: For EU countries, rural areas are those with a population density less than 100 per square kilometre. For Canada, rural areas are those with a population density less than 400 per square kilometre. For the United States, rural areas are those with a population density less than 1 000 per square mile or 386 people per square kilometre. *Fixed broadband coverage*: For EU countries, coverage of NGA technologies (VDSL, FTTP, and DOCSIS 3.0) capable of delivering at least 30 Mbps download was used.
Source: OECD calculations based on CRTC (2020[6]), "Communications Monitoring Report 2020", (Canada); European Commission (2020[7]), "Study on Broadband Coverage in Europe 2019" (European Union); FCC (2020[8]), "2020 Broadband Deployment Report" (United States).

Box 1. Caveats of measuring broadband quality using data from private providers

Broadband quality can be measured in different ways. The OECD has worked systematically on broadband performance and laid the foundation for a harmonised measurement approach in 2012 for one dimension of broadband quality: speeds. It has since then published a number of reports related to this work and has established speed tiers for the subscriptions reported to regulatory authorities in order to construct internationally comparable indicators on advertised speeds (OECD, 2013[9]; OECD, 2014[10]).

As pointed out in the accompanying G20 report "Promoting high-quality broadband networks in G20 countries", advertised broadband speeds may differ from actual speeds experienced by users, and as such, internationally comparable data on actual broadband speeds are not easy to collect. The OECD often relies on external sources to measure "actual" broadband speeds as experienced by users to obtain comparable national average or peak speeds (e.g. Ookla, M-Lab and Steam). It is preferable to use several sources of data to understand the overall level of actual broadband speeds as different entities measure the speed of connections from their perspective of the Internet, using their own methodology (OECD, forthcoming[11]). One such external source is Ookla. This source provides highly granular spatial data on actual broadband speeds, which allows for a territorial analysis, however as noted above, some care is needed in interpretation.

14. Territorial differences in connectivity also translate into user experiences that vary substantially depending on where people live or work, as evidenced by the differences in actual download speeds experienced by individuals in cities compared to those in rural areas (Box 3). Data from self-administered connection speed tests by Ookla (Figure 3) (revealing actual differences in download speeds, as opposed to differences in availability Box 3) show that download speeds over fixed networks in rural areas are on average 31 percentage points[2] below the national average. Download speeds in cities, on the other hand, are on average 21 percentage points above the national average. However, disparities between rural and urban areas are not universally large. In Korea for example broadband quality in the country is relatively equal across the terrain.

15. The analysis in this chapter focuses on reducing the digital divides experienced by people living in different places within countries. While this is a key policy goal, the reduction of regional disparities needs to be accompanied with sufficiently high levels of broadband speeds across regions for people to be able to fully benefit from the economic opportunities and services brought about by digitalisation. Analysis from (OECD, forthcoming[11]) referenced in Box 1, also demonstrates that Korea has a relatively high level of overall fixed broadband download speeds. The finding is similar for countries like Japan and the United States.

Box 2. Understanding territorial disparities using two geographical units of analysis: Territorial level 2 and the degree of urbanisation

This report addresses territorial disparities between urban and rural places. The ideal unit of analysis to use would be territorial classifications that identify regions based on physical access (distance to functional urban areas) and population densities. The most up-to-date standard practice is described in Fadic et al. (2019[12]). However, due to difficulties in classifying non-OECD countries in the G-20 into comparable territorial levels of analysis, the report makes use of categorisation based on areas, rather than small regions. The policy recommendations focus on providing affordable and quality networks across all territories, including regions and areas.

Territorial Levels

In any analytical study conducted at sub-national levels, the choice of the territorial unit is of prime importance. Regions within the 38 OECD countries are classified into two territorial levels reflecting the administrative organisation of countries. The 433 OECD large (TL2) regions represent the first administrative tier of subnational government, for example, the Ontario Province in Canada. The 2 296 OECD small (TL3) regions correspond to administrative regions, with the exception of Australia, Canada and the United States. These TL3 regions are contained in a TL2 region, with the exception of the United States for which the Economic Areas cross the States' borders. For Colombia, Costa Rica, Israel and New Zealand, TL2 and TL3 levels are equivalent. All the regions are defined within national borders.

This classification – which, for European countries, is largely consistent with the Eurostat NUTS 2016 – facilitates greater comparability of geographic units at the same territorial level. Indeed, these two levels, which are officially established and relatively stable in all member countries, are used as a framework for implementing regional policies in most countries.

Source: OECD (2020[13]) *OECD Territorial Grids.* March 2020. https://www.oecd.org/cfe/regionaldevelopment/territorial-grid.pdf

Degree of urbanisation

The degree of urbanisation was designed to create a simple and neutral method of classifying areas that could be applied in every country in the world. It relies primarily on population size and density thresholds applied to a population grid with cells of 1 by 1 km. Roughly speaking:

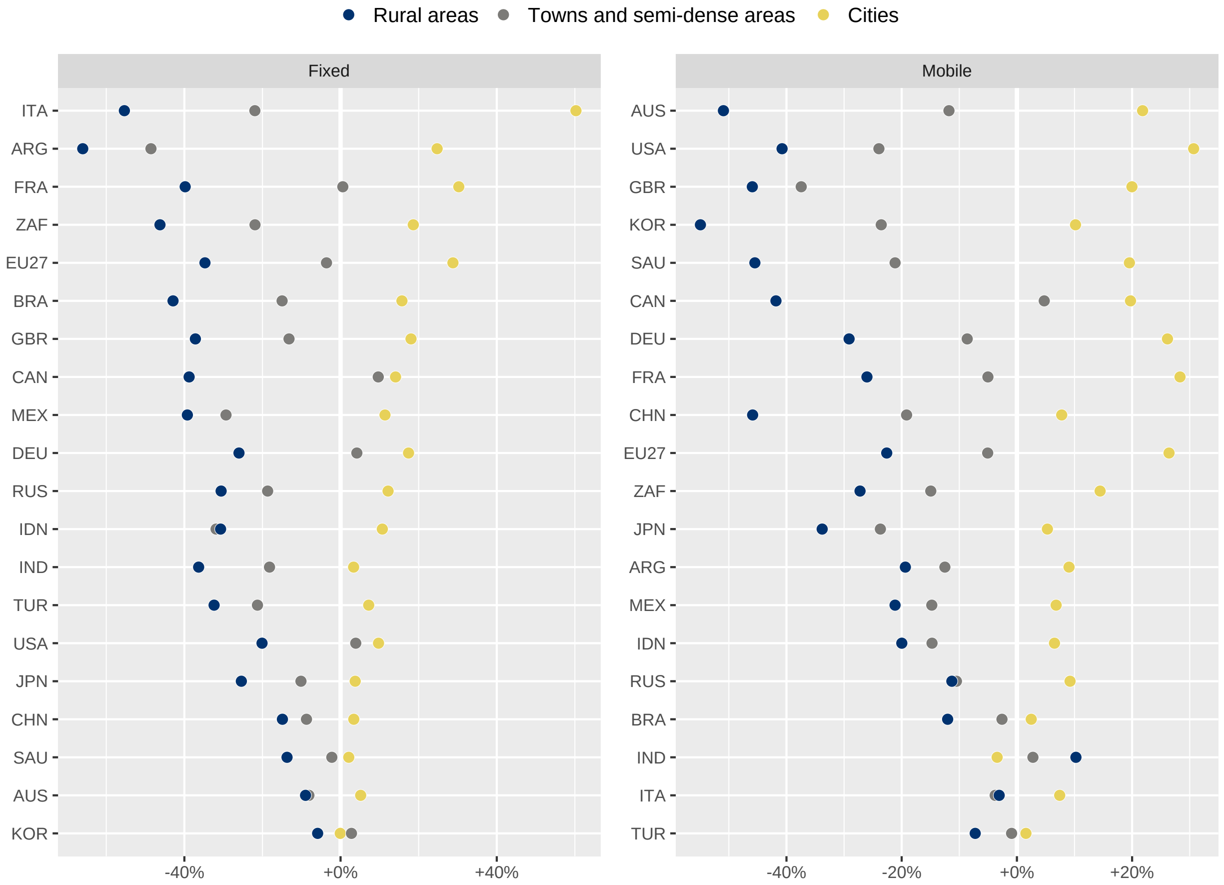
- **Cities** consist of contiguous grid cells that have a density of at least 1 500 inhabitants per km^2 or are at least 50% built up. They must have a population of at least 50 000.
- **Towns and semi-dense areas** consist of contiguous grid cells with a density of at least 300 inhabitants per km^2 and are at least 3% built up. They must have a total population of at least 5 000.
- **Rural areas** are cells that do not belong to a city or a town and semi-dense area. Most of these have a density below 300 inhabitants per km^2.

The degree of urbanisation can be applied also to local units (i.e. municipalities, counties, local authorities, etc.) by looking at the share of population of each local unit living in a city, in a town or a semi-dense area, or in a rural area.

Source: OECD et al. (2021[14]) *Applying the Degree of Urbanisation: A Methodological Manual to Define Cities, Towns and Rural Areas for International Comparisons*, OECD Publishing, Paris/European Union, Brussels, https://doi.org/10.1787/4bc1c502-en.
Source: OECD (2020[13]) *OECD Territorial Grids.* March 2020. https://www.oecd.org/cfe/regionaldevelopment/territorial-grid.pdf

Figure 3. Gaps in download speeds experienced by users, by degree of urbanisation

Gaps estimated as percentage deviation from national averages (2020Q4)

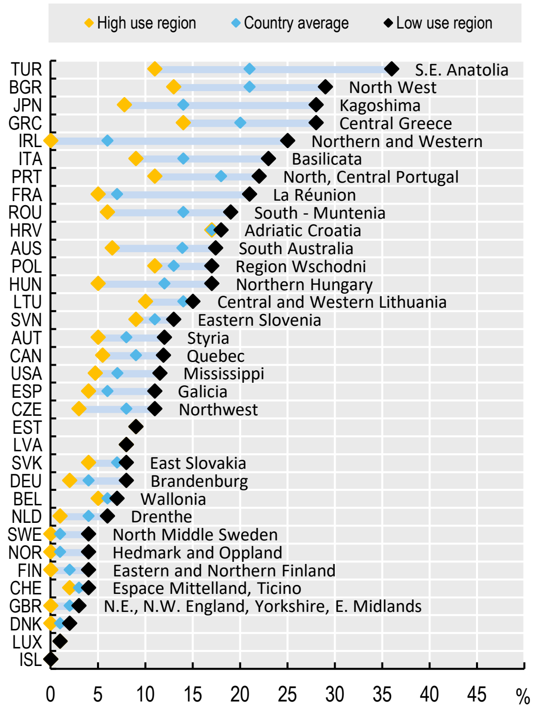


Note: Speedtest data corresponds to 2020Q4. The data for average fixed and mobile broadband download Speedtests reported by Ookla measures the sustained peak throughput achieved by users of the network. Measurements are based on self-administered tests by users, carried over iOS and mobile devices. Aggregation according to the degree of urbanisation was based on GHS Settlement Model (GHS-SMOD) layer grids. The figure presents average peak speed tests, weighted by the number of tests. For further information on the degree of urbanisation, the definition and treatment of the Speedtest data, see Box 2 and Box 3.
Source: OECD calculations based on Speedtest® by Ookla® Global Fixed and Mobile Network Performance Maps. Based on analysis by Ookla of Speedtest Intelligence® data for 2020Q4. Provided by Ookla and accessed 2021-01-27. Ookla trademarks used under license and reprinted with permission.

16. Disparities in mobile download speeds are similar to those in fixed broadband speeds across G20 countries, with a 52-percentage point difference on average between rural areas and cities. On average, mobile download speeds are 24 percentage points higher in cities than the national average, while in rural areas, speeds in mobile downloads are 27 percentage points lower than the average.

17. In order to seize the benefits of digitalisation, access to communication infrastructure needs to be complemented by the widespread adoption of digital technologies and by a minimum level of digital skills (OECD, 2020[15]). Recent evidence from OECD countries shows that there is still a clear regional divide in the take-up of digital technologies, as evidenced by the large number of households that are still not using the Internet in some regions (Figure 4). On average, there is a 7.7 percentage point gap in the share of people using the Internet between the regions with the highest and lowest use. In countries like Ireland, Turkey and Japan, the gap can be greater than 20 percentage points.

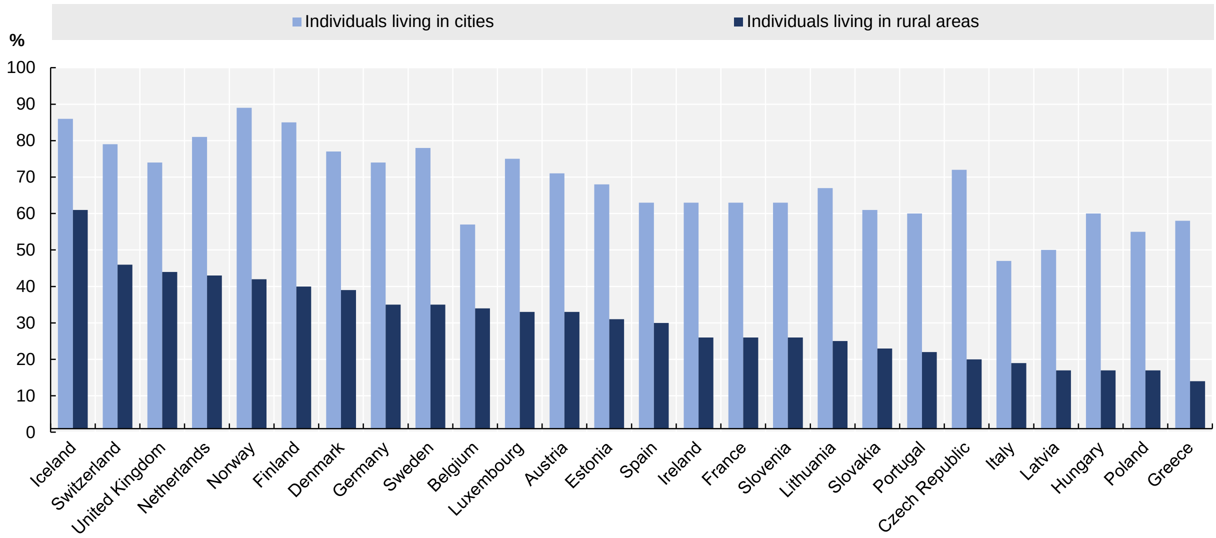
Figure 4. Percentage of people not using the Internet, large regions (TL2)



Note: Large regions (TL2). 2020 or latest available year: Australia, 2017; Japan, 2018; Canada, Chile, France and USA, 2019. Data on regions is not available for Luxembourg, Iceland, Estonia or Latvia. Internet use is expressed as the percentage of individuals that do not use the Internet once per week (EU), as the percentage of households that have a computer but do not have an Internet subscription (United States), that report not having Internet use from home at the time of interview (Canada), or where no member of the household has used the Internet in the past year (Japan).
Source: OECD calculations based on Eurostat (2021), "Community Survey on ICT usage in households and by individuals" (Table: isoc_r_iuse_i), Statistics | Eurostat (europa.eu); U.S. Census Bureau (2020), "American Community Survey" (Table: B28003) U.S. Census (data.census.gov); Statistics Canada (2020), "Dwelling characteristics and household equipment at time of interview, Canada, regions and provinces" (Table: 11-10-0228-01), https://doi.org/10.25318/1110022801-eng; Ministry of Internal Affairs and Communications of Japan (2018), "Communication Usage Trend Survey Household Edition" Data | Ministry of Internal Affairs and Communications (data.go.jp).

18. Opportunities to make the most of connectivity in rural areas are hampered simultaneously by the level of digital skills and connectivity divides. In OECD countries, rural areas have a lower share of individuals with at least basic digital skills than in cities (Figure 5). In some cases, these are paralleled by the divide in communication infrastructure. The divide in skills can be substantial in countries such as France and Italy, which also record some of the highest gaps in fixed broadband download speeds. While improving digital skills will not directly trigger better policies to reduce spatial disparities in access to quality communication infrastructure and services, they may be symptomatic of limited connectivity that proliferate the territorial digital divide.

Figure 5. Share of individuals living in rural areas and cities with "basic" or "above basic"* digital skills (2019)



Notes: Digital skills indicators are composite indicators based on selected activities related to Internet or software use performed by individuals aged 16-74 in four specific areas (information, communication, problem solving, and software skills). It is assumed that individuals having performed certain activities have the corresponding skills. Therefore, the indicators can be considered as proxies of the digital competences and skills of individuals. *Above basic level of skills: the individual scored "above basic" in all four domains (information, communication, problem solving, software skills). Not all OECD countries covered by data source. For further information on the Eurostat classification of areas by degree of urbanisation, see https://ec.europa.eu/eurostat/web/degree-of-urbanisation/background.
Source: (OECD, 2021[16]) based on Eurostat (2021), "Community survey on ICT usage in households and by individuals" (Indicator: Individuals' level of digital skills"), Statistics | Eurostat (europa.eu)

Box 3. Assessing urban-rural disparities in broadband download speeds

The assessment of urban-rural disparities in broadband download speeds relied on two spatially granular sources of data:

- Average fixed and mobile broadband download speed data from self-administered tests performed by individuals across the globe through Speedtest by Ookla, aggregated to web Mercator tiles at zoom level 16 (approximately 610 by 610 meters at the equator).
- GHS Settlement Model (GHS-SMOD) layer grids giving the settlement classification of 1 by 1 km cells according to the degree of urbanisation (Box 2).

The data for average fixed and mobile broadband download speed tests reported by Ookla measures the sustained peak throughput achieved by users of the network. In practice, when a user asks for a Speedtest, the device pings nearby dedicated testing servers, saturates the network connection, and measures the sustained peak speed achieved by the device during the test window. Therefore, the measured indicator does not reflect the day-to-day speeds experienced by users, but rather the actual maximal speeds attainable by the network connection when a users' device sends the maximum amount of data to one of 14 000 testing servers. Speed tests are performed at any hour of the day.

For each country, speed tests tiles were categorised according to degree of urbanisation classification of the underlying GHS-SMOD layer grid. National download speed averages for each category—cities, towns and semi-dense areas, and rural areas—were computed weighting by the number of tests per tile. Information is presented as deviations from the national average to highlight within-country differences in the quality of broadband connections.

Source: Speedtest® by Ookla® Global Fixed and Mobile Network Performance Maps. Based on analysis by Ookla of Speedtest Intelligence® data for 2020Q4. Provided by Ookla and accessed 2021-01-27. Ookla trademarks used under license and reprinted with permission. Pesaresi et al., (2019[17]) GHS settlement grid, updated and refined REGIO model 2014 in application to GHS-BUILT R2018A and GHS-POP R2019A, multi-temporal (1975-1990-2000-2015), R2019A. European Commission, Joint Research Centre (JRC) [Dataset], doi:10.2905/42E8BE89-54FF-464E-BE7B-BF9E64DA5218 PID: http://data.europa.eu/89h/42e8be89-54ff-464e-be7b-bf9e64da5218

Key policies to bridge connectivity divides

19. Ubiquitous access to high quality and affordable communication services is key to achieve an inclusive digital transformation. The global pandemic has only made this more evident, underscoring the need for equal access to high-quality connectivity for everyone regardless of where they live.

20. This section will discuss different policy mechanisms to extend connectivity that have proven to be efficient. These include fostering competition, promoting investment and easing infrastructure deployment. All of these measures are important tools that have been used by various countries to spur the expansion of high-capacity communication networks, including in underserved areas.

21. In a second step, the section focuses on policies and regulatory measures that particularly foster broadband development and deployment in rural and /or remote areas.

Overarching policies and regulatory measures to expand connectivity

22. Expanding connectivity to achieve an inclusive society is at the heart of the policy agenda in all G20 countries. A growing number of G20 countries consider the Internet as a basic right for citizens, and many have changed their universal service frameworks to include broadband. Furthermore, many countries have established connectivity targets through national broadband plans or digital strategies, with many of these plans increasingly aiming for higher speeds (e.g. "Gigabit" and even 10 Gbps broadband connections).

23. Overarching policies that promote broadband deployment, such as promoting competition and investment, and reducing network deployment costs, are the main policies used to extend broadband networks and have proven to be effective in many G20 countries, and are therefore fundamental to bridge digital divides of a geographical nature.

24. To expand connectivity, and spur economic development, a sound regulatory and institutional framework can go a long way for two main reasons.

- First, the inherent cost structure of communication markets (i.e. high investment needs and fixed costs with barriers to entry) is conducive to oligopoly/monopoly market structures if left unregulated. A determining factor that has driven communication prices down and extended coverage of broadband networks in most OECD countries is regulation that fosters competition.
- Secondly, market players undertake the vast majority of the investment for network rollout in the communication sector; therefore, policies that reduce barriers and costs of network deployment and provide incentives to invest are key to extend networks and increase their quality.

25. This reduces the need for public investments to areas where business cases are not likely to be viable, and where alternative approaches (e.g. through public-private partnership or public funding) might be required. Combining market forces with alternative approaches will be key to further expand

connectivity, also through the different economic recovery packages currently established by various G20 countries.

26. Therefore, overarching policies that foster competition, promote investment and ease infrastructure deployment are important tools to spur the expansion of high-capacity communication networks, including in rural and remote areas that are often underserved or completely unserved.

The need to foster competition for an inclusive digital transformation

27. Promoting competition is one of the strongest levers to extend connectivity and increase quality, including to underserved populations.[3] In multiple instances, it has been observed that an increased level of competition has led to more innovation, increased investments and reduced prices for communication services and thus increased affordability, a key barrier for Internet adoption. Prices, for example, depend greatly on the competitive conditions of the market in each country, and in some instances, they also depend on regulation for specific services at a wholesale level. In a sector with high fixed costs and barriers to entry, as is the case for the communication sector, the institutional and regulatory framework weighs heavily on the resulting market structure. As such, it has a direct influence on the affordability of communication services and the discipline applied to prices by competition (OECD, 2021[18]).

28. Promoting competition has brought benefits in the following examples:

- In Mexico, increased competition since the Telecommunication Reform in 2013 led to a price decline of up to 84% in the mobile broadband market, and added 72 million mobile broadband subscriptions from 2012 to 2020, which is the equivalent to slightly more than the combined population of Colombia and Chile. This allowed many people in Mexico – especially from low-income households – to connect to the Internet for the first time.
- In India, Reliance Jio entered the market in 2016 and now has over 400 million subscribers and one of the lowest prices in the world, connecting millions of the previously unconnected.
- In France, the entry of a fourth mobile operator in 2012 (Iliad) resulted in steady price declines[4] (Grzybowski et al., 2017[19]). It also resulted in innovative commercial offers increasing (Bourreau, Sun and Verboven, 2018[20]). Investments have been steadily increasing in the communication sector since 2008, with total investment up by 59.6% in the 2008-19 period, and 40.9% in the 2012-19 period (Arcep, 2020[21]).

29. Increased competition in communication markets has not only rendered these services more affordable, but has also played a significant role in broadband development in G20 countries. Insufficient infrastructure competition between different players may, in some instances, necessitate regulatory intervention or oversight, which explains why integrated incumbents in OECD and G20 countries were, and in many cases still are, subject to regulatory measures (OECD, 2019[22]).

30. *Ex ante* pro-competitive regulation in wholesale markets, for example, is widely used to increase infrastructure competition between operators as well as retail-based competition. The United Kingdom regulated incumbent, BT’s Openreach, offers unbundled access to fibre optic and copper networks at wholesale prices (European Commission, 2018[23]).

31. End-to-end infrastructure competition, where different operators compete with their own network, on the other hand, is more evident in mobile markets in OECD countries. However, recent initiatives of shared infrastructure, which in some cases are regulated and in others not, are also emerging in mobile networks (e.g. Mexico and Peru). Such is the case of Mexico, where the government opted for a Private Public Partnership (PPP) national wireless wholesaler network using the 700 MHz band, the “Red Compartida” (Box 3). Another example is “Internet para Todos” in Peru that has connected 6 000 localities across Peru with more than 800 base stations with 3G and 4G technologies (Internet para Todos, 2020[24]). MNOs and MVNOs can access these networks under fair, reasonable and objective conditions to provide affordable retail communication services. It is still too soon to determine the success of these policies.

However, they do suggest the need for innovative models in infrastructure deployment and the role competition may play.

Promoting investment and easing infrastructure deployment

32. An enabling domestic environment plays a large role in attracting investments, and one way of providing incentives to invest is by reducing network deployment costs. Therefore, policies that reduce barriers to broadband deployment and thus make investments easier and cheaper by communication operators are further key drivers of expanding and upgrading communication networks, and thus play a major role in bridging connectivity divides.

33. To illustrate, one effective way to ease infrastructure deployment and increase the speed of deployment is through a reduction of network approval and construction times. Rights of way are crucial when it comes to the deployment of communication networks in the last mile. For example, harmonised procedures to get all necessary permissions are needed for the development of high-quality networks, where municipalities play a key role. As such, many G20 countries are working to reduce approval and construction times for network rollout. Other than reducing the costs of deployment, other public interests at a municipal level may exist, such as landscape protection and environmental considerations, which should also be considered (OECD, 2019[25]).

34. In addition, streamlining access to rights of way can reduce the costs of civil works and therefore provide an important impetus to stimulating the roll-out of next generation networks and, in particular, fibre. A public right of way permit is usually an agreement between the government and an applicant (OECD, 2008[26]). The granting of public rights of way usually requires the active participation of public authorities, often at different levels of government in managing or authorising the civil works needed in constructing ducts or other infrastructure required for networks.

35. Many G20 countries are aiming to streamline rights of way, in particular with respect to the deployment of 5G networks which, in many cases, require installing a large amount of small cells across countries. For example, in the United States, the Federal Communications Commission (FCC) issued an Order titled, "*Accelerating Wireless and Wireline Broadband Deployment by Removing Barriers to Infrastructure Investment,*" adopted on September 2018 (FCC, 2018[27]). The decision concerns the amount that municipalities may reasonably charge for small cell deployment. In offering guidelines for determining this value, the FCC cited the rules of twenty states that limit upfront pole fees to USD 500 for use of an existing pole, USD 1 000 for installation of a new pole, and recurring fees of USD 270 (OECD, 2019[25]).

36. Another example for facilitating network deployment can be found in the European Electronic Communications Code (EECC). The EECC (article 57) also aims to minimise authorisation requirements and costs of the deployment of small cells. According to this EECC provision, competent authorities shall not subject the deployment of small-area wireless access points, i.e. small cells, which comply with certain characteristics laid down in a future implementing act, to any individual town planning permit, to other individual prior permits, or to any fees or charges going beyond the demonstrated administrative charges (European Commission, 2018[28]). In 2019 and 2020, the European Commission held two public consultations on a "light deployment regime" for small cells to facilitate their rollout. On June 2020, the European Commission adopted the regulation specifying the physical and technical characteristics of small cells for 5G networks within the European Union (European Commission, 2020[29]).

Making information available for operators and increasing deployment efficiency

37. Increased access to information and public assets also plays a crucial role for broadband deployment. For example, a lot of the time in the deployment process in mobile infrastructure may be spent

on the determination and acquisition of locations to build towers. To ease this process, countries can increase the transparency of and access to information about public assets.

38. For example, they could consider establishing a one-stop online portal that geo-references publicly owned buildings available for lease as the one that was built up in Mexico. In Mexico, the National Telecommunication Infrastructure Information system (Sistema Nacional de Información de Infraestructura, SNII) -approved by the Mexican communication regulator (IFT), includes useful information on locations where concessionaries can deploy communication infrastructure on public assets, such as buildings.[5] This inventory aims at revealing the availability, status, and price of this infrastructure to increase efficiency in deploying communication networks, lower the costs for infrastructure deployment, and increase coverage across the country.

39. With the aim of reducing deployment costs, Belgium created a central electronic counter in each region for applying for licences to roll out infrastructure and for granting licenses swiftly, promoting access to existing infrastructure. In addition, the country published guidelines and issued a "fibre ready" label for citizens that plan to build or renovate their residences. Based on the European Union Directive ("on measures to reduce the cost of deploying high-speed electronic communications networks") (European Parliament, 2014[30]), it also seeks to optimise the co-ordination of roadworks and the distribution of costs among network operators (telecommunication companies, cable companies, power grid operators, water companies, transport, etc.) participating in the joint roadworks, as the main cost component of network deployment are civic works.

Tailored policies and regulation to close connectivity divides in rural and remote areas

40. While policies to promote competition and private investment, as well as independent and evidence-based regulation, have been very effective in extending broadband coverage in G20 countries, including in rural and remote areas, some gaps may remain. In areas where market forces have not proven to be able to fulfil policy objectives (i.e. in terms of broadband coverage or service quality), additional interventions by governments may be necessary.

41. G20 countries have deployed a range of tailored approaches in response to these situations which can be found at all levels of government. While some governments have established minimum service targets, for example minimum download speeds, that they wish to see universally available, broadly speaking, the policy priority should be on delivering high quality broadband services at symmetric speeds, across the entire territory. This is necessary to enable the delivery of essential services (such as online learning), to support the local business environment in rural and remote areas and to support a level playing field for these businesses vis-à-vis those in urban areas. Some of the tailored initiatives to bridge connectivity divides in rural and/or remote areas, in addition to promoting market forces and reducing deployment costs, include:

- demand aggregation models to ensure financial viability of projects,
- public private partnership (PPP) initiatives,
- public funding to expand connectivity in rural/remote areas, often making use of market mechanisms, such as reverse auctions, to provide funding to market players to deploy their networks in rural and remote areas,
- bottom-up approaches: open access municipal and community-led networks,
- addressing particular "the last mile" challenges in rural and remote areas, and
- coverage obligations in spectrum auctions (for wireless networks).

Demand aggregation models to ensure financial viability of projects

42. In areas where it is economically difficult to justify the roll out of broadband networks, the model of demand aggregation can be used to increase certainty for investors and operators. Demand aggregation models help investors by essentially signing up customers in advance, coordinating and bundling demand to increase the potential profitability, economies of scale and/or the certainty of the business case for network expansion (OECD, 2018[3]). For example, a company may require that a certain percentage of households in a given community commit to using their broadband service for a certain period of time before they proceed with the deployment. In some cases, the risks for the private investor may be further reduced when a local organisation (i.e. a municipality or co-operative organisation) handles the demand aggregation process, securing commitments from residents and businesses to subscribe to the service and then contracting the private sector operator to develop the network (OECD, 2018[3]). Demand aggregation is a tool that may be used independently or in combination with other approaches. Some OECD and G20 countries have used demand aggregation tools to foster broadband roll-out. In Germany, for example, demand aggregation is used to extend connectivity in particular in rural and remote areas, where 30 to 40% of households are expected to commit before deploying fibre-to-the-home (FTTH) networks. One of the most prominent companies in Germany using this model is *Deutsche Glasfaser*. The company reports that so far it has installed over 500 000 FTTH connections using this model (Deutsche Glasfaser, 2020[31]).

43. Local cooperatives in the Netherlands have also registered and aggregated user demand from households, and then contracted a private company to build and operate a next-generation broadband network. Lijbrandt Telekom and OnsNet, for example, have applied this model to identify areas for private-sector investment in next-generation broadband networks. The demand registration schemes have all involved consumers making a contractual commitment for a service several months in advance of that service becoming available. This contrasts with most of the schemes in first-generation broadband deployment, which were more an 'expression of interest' with no firm commitment (Analysis Mason, 2008[32]). Case studies on demand aggregation in Analysis Mason (2008[32]) suggest that interventions involving demand aggregation tend to break-even relatively quickly.

Public-private partnerships: sharing risk and investment

44. For many years, several G20 countries have followed a path of continued liberalisation of the communication sector with a focus on investments by the private sector and competition among private companies. More recently, some countries have started to provide public funding with a focus on remote and rural areas, and some even deploy national broadband networks once they determine that there is insufficient competition in certain areas. Public funding ranges from grants for public-private partnerships (PPPs), to funding entire national broadband networks. Not all funding and deployment cases have been successful.

45. Some governments (national and subnational) may choose to invest alongside private actors through public-private partnerships to share the risks associated with the creation, development and operation of an infrastructure asset, especially in areas where positive business cases are hard to achieve. Public-private partnerships may diminish reliance on public resources derived from taxation or universal service funds. Some examples of public-private partnership models are found in Box 4.

46. Some PPP initiatives have been designed as open access networks, providing wholesale access capacity on fair and reasonable terms with a certain degree of transparency and non-discrimination. If elaborated well, this model enables more competition and innovation at the retail level. If public funding is awarded to these networks (e.g. through preferential loans, subsidies), typically, certain open access conditions can be imposed and companies need to comply with these conditions in exchange for public funds. This type of model has been used to expand connectivity to rural and remote areas in some countries, such as in New Zealand, where it is intended to ensure that public funding promotes competition

in these areas. Singapore represents another example of a nationally-catalysed PPP initiative to create an open access network that is structurally separated and has generated positive results in the market (OECD, 2019[22]).

Box 4. Examples of public-private-partnership models

United Kingdom: Community Fibre Partnership

British broadband network operator Openreach offers a community fibre partnership initiative whereby communities can register their interest in improved connectivity and then work with the company to build a customised fibre solution to bring fibre broadband to the community's homes and businesses. These projects involve a cost-sharing contract between Openreach and the local community which sees the company paying part of the cost and the community paying the rest. Sources of funding for the public contribution at the local level can include the United Kingdom national government's Gigabit Broadband Voucher Scheme. As of 2019/20, Openreach has signed 1330 partnerships connecting 122 000 homes and businesses to fibre through this approach (Openreach[33])

United States: Westminster, Maryland

Westminster, Maryland (population ~18 000), is a community on the outskirts of Baltimore that has developed a public-private partnership to improve the quality of broadband services for its residents. While the local government recognised the need to improve the broadband service in the community, it also recognised that it was not was not well-equipped to accomplish this alone, lacking a municipal organisation with the expertise necessary to tackle this technical challenge. Through an innovative approach based on a public-private partnership, Westminster decided that it would build, own and maintain a fibre network, but would look to a private sector partner to light the fibre, deliver services and handle relationships with customer residents and businesses. This approach meant the town did not need to have any involvement in the network's operations. Under the terms of the partnership, Westminster is building and financing the fibre network through a bond offering, while a private company is leasing the fibre. The company was also required to commit to building an open access network by opening its operations to competitors through wholesale services within two years so that other providers can then enter the market. The model shares the risk between the town and the company. While Westminster took on the bond to build the network, the payment structure with the company requires that it pay the town a monthly fee for every premise the fibre passes, irrespective of whether those premises are subscribers, thus the company was financially obligated to the municipality even if it had no customers, ensuring it would be motivated to sign up as many subscribers as possible (Hovis et al., 2014[34]).

Republic of Ireland: National Broadband Ireland (NBI)

The Government of Ireland has embarked on a major project to provide nationwide access to fibre connectivity. Two features of the NBI initiative are of particular interest:

- The new fibre network is being built with state support only in those areas of the country where the private sector would not invest (i.e., the government's intervention will not apply in the major urban areas where the private sector is providing connectivity); and,
- The network is being built using a public-private partnership model, which reduces the government's costs and exposure to risk and means that the new network that is built will be privately owned, operated and maintained.

This process began in consultation with the private sector to determine which areas of the country would be connected on a purely commercial basis. The major incumbent provider, Eir (Eircom Limited), a formerly state-owned telecommunication company, indicated which parts of the country they had already connected and which they planned to connect in the near term, and the remaining territory was deemed an intervention area, where state support would be needed. The intervention area is home to about 1.1 million people and 540 000 premises, in rural and remote areas of the country. Having determined the intervention area, the government then partnered with a private-sector investor through a PPP. National Broadband Ireland (NBI) is a privately owned company that aims to deliver advanced connectivity to all premises in the intervention area, installing up to 146 000 km of new fibre. NBI's investment will be backed by state subsidies of up to EUR 3 billion over the 25 year term of the agreement (USD 3.7 billion). Through the PPP, NBI will own the network and will generate income by selling wholesale access to service providers, however NBI will also carry risk, as the government's support is capped so any cost overruns will be borne by the private investors (Department of Communications, Climate Action & Environment, 2019[35]).

Mexico: Red Compartida

The telecommunication constitutional reform in Mexico (2013) mandated for the deployment of the Red Compartida, a wholesale wireless communication network for the provision of services in an unbundled and non-discriminatory manner. This initiative was designed as a self-financed public-private partnership, awarded to the consortium Altan Redes in 2016 through a 20-year concession. The government provided spectrum (i.e. the right to exploit at least 90 MHz of spectrum in the 700 MHz band), in addition to fibre optic strands from the national electricity company, for the successful deployment of the network (OECD, 2017[36]).

This wholesale-only 4G network commenced operations in March 2018. Part of the rationale for creating the Red Compartida was to improve communication services in underserved areas, with a final target of 92.2% of the population within five years of commencing operations. Red Compartida also sought to improve the level of competition, particularly in underserved areas by offering data capacity to operators, mobile network operators (MNOs) and MVNOs (OECD, 2019[22]).

Public funding and subsidies for rural and remote connectivity

47. Policies that promote competition and private investment, together with independent and evidence-based regulation, should be the first priority. This will ensure the private sector delivers high quality affordable broadband services in almost all areas, including many underserved rural and remote regions. For those gaps that may remain, public funding remains commonplace in many OECD countries. There are several ways these funds can be delivered.

48. While most of the investment in broadband deployment usually comes from the private sector, it has been complemented by public funding in many G20 countries in the form of state aid. Estimating the amount of public financing required to reach connectivity targets, as well as which geographical areas should be subject to state-aid, is crucial both to make the best use of public funds, as well as to avoid crowding-out investment by private players. Nevertheless, policy makers need to be cautious of the possibility of state aid hindering incentives by the private sector to deploy networks. Sweden, for example, conducts prior market analysis to identify the areas that are not commercially attractive, and once the areas are detected, public consultations of the planned financed expansions are held where private operators can identify if these plans clash with a planned commercial development (Government Offices of Sweden, 2017[37]).

49. Often, the financing to expand connectivity in rural and remote areas derives from national broadband plans. In addition, sub-national governments may also play a role. Wherever possible, national and subnational governments should work together to bridge the gaps and ensure that networks are deployed in these areas. For example in March, 2021, the Government of Canada and Government of

Quebec announced an example of such a partnership, with the two levels of governments agreeing a 50-50 co-investment of a total of CAD 826.3 million (USD 686 million) to expand broadband services to around 150 000 homes in rural Quebec by September 2022. The funds will be used by six private operators to expand their networks (Government of Canada, 2021[38]).

50. Many G20 member countries have specific programmes for expanding broadband access in rural and remote areas, in addition to the funds derived from national broadband plans. For example, in Korea, the 2010-2017 rural connectivity project called "Broadband Convergence Network" (Rural BcN) connected 13 473 remote rural villages (i.e. of less than 50 households) to 100 Mbps broadband access. In Spain, a combination of pro-competitive regulation and state aid (public funding) has been used to boost high- quality broadband coverage in all areas of the country (Box 5). In addition, the accompanying G20 report on "Promoting High Quality Networks in G20 countries" highlights that in response to the economic crisis derived from the COVID-19 health emergency, several G20 countries (e.g. France, the European Union, the United Kingdom, and the United States) have placed broadband infrastructure deployment projects as a fundamental element in their economic recovery packages (OECD, forthcoming[11]).

Box 5. Examples of specific funds to extend broadband access in rural and remote areas

Korea: Investing in rural area connectivity and its economic effects

While Korea achieved fibre-based fast and reliable broadband networks covering large parts of the country, private sector investment sometimes lagged in rural and remote areas, mostly due to issues around the economic feasibility of broadband deployment. To tackle this problem, the Korean National Information Society Agency (NIA) joined efforts with local governments and the network operator KT to build broadband networks in small rural communities (i.e. villages with less than 50 households) to enable access to the 100 Mbps or higher speed Internet to residents in those communities. The eight year rural connectivity project "Broadband Convergence Network" (Rural BcN), which was finalised in 2017, managed to bridge the connectivity divide in 13 473 rural villages, including 360 villages part of islands.

The results of a recent survey show that the total economic benefits of the Rural BcN Project amount to around KRW 160.45 billion (USD 138 million), comprised by estimated annual average cost-savings of KRW 28 billion (USD 24 million) and by an estimated effect derived by the increase of household income of KRW 132.45 billion (USD 114 million).[1] The total amount of budget invested into the project was approximately KRW 142 billion (USD 121.8 million) over a period of eight years, where the private operator KT funded half of the project, 25% of the budget was provided by the national government; and another 25% by each local government.

Note: 1. Using exchange rate of 1165.499 KRW/USD from OECD (2020[39]).
Source: MSIT and NIA (2017) "Broadband convergence Network, 8 Years of Rural Broadband convergence Network Project in Korea," Ministry of Science and ICT in Korea (MSIT) and the National Information Agency (NIA), Seoul, November 2017

Spain: Pro-competitive wholesale regulation and targeted public funds (state aid)

In recent years, Spain has emerged as a connectivity leader in Europe, with the country's regulatory environment a key driver of private sector led investment in fibre networks. Two regulatory measures have been key:

- Third party network access obligations on the formerly state-owned incumbent, Telefonica, were capped at 30 Mbps, meaning that new entrants could use Telefonica's network to deliver connectivity at up to those speeds, with Telefonica obligated to sell them wholesale access at regulated pricing; and,

- Telefonica was obligated to permit new entrants to use their ducts to build their own networks.

Together these rules provided incentives for Telefonica and others to install fibre, since at speeds above 30 Mbps they would not have to provide access to competitors, strengthening the business case for their investment by reducing the time needed for them to achieve positive returns. The result has been a rapid rollout of FTTH connectivity across the country, with fibre as a percentage of total fixed broadband connections growing from 35% in 2016 to 70% in June 2020 (OECD Broadband Portal). The supportive regulatory environment is bolstered by public funding outside of the cities. Backed by funding from the European Regional Development Fund, Spain has delivered two major programmes to subsidise connectivity investment in these areas:

- Next Generation Broadband Expansion Programme (NGBEP).This programme is intended to support the investment effort of private operators, with the aim of extending the deployment of high-speed broadband networks (more than 100 Mbps) to the most rural areas. From 2013 to 2020, the programme held annual application windows for providers to propose projects through a competitive application process. Funding was a mixture of grants and repayable loans. Beneficiaries of the aid are obliged to offer wholesale access to the subsidised infrastructure for a minimum period of seven years from the date of entry into service. Funding over the seven years totalled approximately EUR 540 million, around 80% of it in loans and 20% grants.
- The 300x100 Project. Following on from the NGBEP, this 300x100 project aims for even faster connections, targeting connectivity of at least 300 Mbps to 100% of premises nationwide. The project is distributing up to EUR 525 million to fund specific projects in rural areas.

Source: Government of Spain, Ministry of Economy and Business, https://avancedigital.mineco.gob.es/en-us/Participacion/Paginas/Cerradas/PEBA-NGA-2019-2021.aspx

51. Policy makers and regulators have increasingly used market mechanisms, such as competitive tenders and reverse auctions, wherever possible to make the use of scarce public funds more effective in terms of meeting objectives in geographical areas that are underserved by broadband networks. For example, G20 countries such as Italy, Korea, the United Kingdom and the United States have used reverse auctions to this effect. A recent example of the use of reverse auctions is the Rural Digital Opportunity Fund (RDOF) in the United States (Box 6).

Box 6. The RDOF fund in the United States: a reverse auction mechanism

The Rural Digital Opportunity Fund (RDOF) aims at bridging the connectivity divide in rural and remote areas in the United States. Through a two-phase reverse auction mechanism, the FCC will fund up to USD 20.4 billion over ten years to finance up high-speed broadband networks ("up to Gigabit speeds") in rural and remote areas. Phase I of the project will grant up to USD 16.4 billion in funding and will target over six million homes and businesses in census blocks completely unserved by voice and broadband with speeds of at least 25 Mbps. The funds will be awarded by reverse auction in a process favouring faster download speeds, but also those willing to take the lowest amount of grant per customer.

Source: FCC (2020[40]), *Implementing the Rural Digital Opportunity Fund (RDOF) Auction*, https://www.fcc.gov/implementing-rural-digital-opportunity-fund-rdof-auction

52. In some G20 countries, voucher programmes have been established to assist consumers in getting connected. In some cases, these are to help low-income households pay the subscription fee, while

in others they fund last-mile connections with the aim of encouraging service providers to expand their networks and to encourage communities to work together on the issue. These vouchers are a form of a subsidy programme, with the distinction that they permit recipients, rather than the government, to decide which provider and broadband technology is best suited to their needs. The United Kingdom Gigabit Broadband Voucher Scheme (GBVS) is an example (Box 7).

Box 7. United Kingdom: broadband vouchers for consumers and businesses

Under the GBVS, homes and businesses in rural areas of the United Kingdom are eligible for funding towards the cost of installing gigabit-capable broadband when part of a group scheme. Group projects are when two or more residents and/or SMEs get together to combine their vouchers towards the shared cost of installation. Single connections are not eligible for additional funding. Rural premises with broadband speeds of less than 100 Mbps can use vouchers worth GBP 1 500 (USD 2 130) per home and up to GBP 3 500 (USD 4 970) for each small to medium-sized business (SME) to support the cost of installing new fast and reliable connections. The voucher funding is transferred directly to the consumer's selected supplier on verified completion of the line installation. There are more than 450 registered suppliers, participating in the programme, including major companies like BT, Virgin Media and TalkTalk, and also small co-operatives like B4RN (described in Box 8).

Source: United Kingdom, Gigabit Broadband Voucher Scheme, https://gigabitvoucher.culture.gov.uk/

Bottom-up approaches: open access municipal and community-led networks

53. Several G20 countries have seen successful examples of municipal and community-led networks being developed in rural areas, often in response to perceived underinvestment in the community by the incumbent network operators.

54. Locally-led efforts can benefit from greater cooperation with local communities and governments, especially since the permits for access to rights of way usually lie at the local level. In some cases, these networks benefit from voluntary access to land and voluntary labour to help construction. 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.

55. 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[41]), are used in several OECD countries to promote fibre deployment in cities, smaller towns and surrounding regions. Implementing bottom-up models to finance and deploy high-speed networks has been an approach for assisting rural and remote areas to cope with continuously growing demand for higher broadband capacity. Municipal networks can extend the connectivity in regions where deployment by national communication companies is lacking or deemed unprofitable. In areas in which coverage is provided by national players, municipal networks are likely to spur competition.

56. 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[42]). Institutional framework conditions may be key to fostering bottom-up initiatives that seek to expand connectivity in rural and/or remote areas. For example, in Mexico, the rise of community networks has been facilitated by changes brought by the 2013 telecommunication reform, and implemented with the 2014 sector law (Ley Federal de Telecomunicaciones y Radiodifusión,

LFTR). The licensing regime changed to a simple class-licensing regime (except for resource scarcity restraints, i.e. spectrum), where spectrum licences are granted for a determined use (commercial, public, social use). In Mexico, social use spectrum licences include community and Indigenous networks with non-profit purposes (OECD, 2017[36]). In Brazil, the communication regulator (Anatel) explicitly recognised community networks as an option for Internet access in Brazil (Anatel, 2020[43]).

57. Deployment costs of fibre are much higher in sparsely populated areas than in urban ones. As such, state aid can be used to offset these differences. In addition, in these areas commercially "unattractive" areas, local interest groups and initiatives, such as community networks, can help both lower costs and increase revenues given their knowledge of local conditions. For example, in Sweden, the liberalisation of the telecommunication market in the 1990s not only encouraged alternative operators to expand and the creation of municipal networks, but also local communities to form co-operatives for the rollout of fibre networks, commonly referred in Sweden as "village networks". The "village fibre" approach is based on the premise of community involvement to plan, build and operate local fibre networks in co-operation with municipalities and commercial operators. The deployment of fibre networks through village fibre is facilitated by consumers' willingness to pay in Sweden upfront fees of around USD 2 300 to connect single dwelling units, and the possibility to apply for a subsidy from public funds. Given that village networks are deployed in areas where no commercial operators are deploying fibre networks, they meet the key criteria for state aid. Compared to commercial broadband projects, village fibre projects can achieve cost savings of some 50% using an innovative handling of permissions as well as excavation and voluntary work. A further reduction of some 25% is achieved through state aid, making the connection fee equivalent to that of urban areas (OECD, 2018[44]). Examples on municipal and community networks are found in Box 8.

Box 8. Examples of municipal and community networks

Municipal fibre networks in Sweden and Finland

In rural and remote areas, municipal community co-operatives have been formed to build fibre networks in Sweden, Finland and other countries.

A decisive factor in Sweden's high fibre take-up is that municipal networks have been widely deployed in the country since the liberalisation of the communication market (OECD, 2015[41]). Swedish municipalities began building their own fibre networks in the mid-1990s following the liberalisation of the telecommunication market (OECD, 2018[44]). Within a few years, these networks grew to cover entire municipalities, serving homes and businesses and connecting cell towers. Most Swedish municipal networks provide retail "operator" neutral network infrastructure based on fibre to the building or fibre to the home (FTTB/FTTH). That is, their business model relies on open networks where they act as physical infrastructure providers offering wholesale access to retailers on a non-discriminatory basis (OECD, 2018[44]). This has led to a notion of "open" municipal networks, which contrasts with other business models that rely on completely vertically integrated telecommunication operators present both in wholesale and retail markets (OECD, 2015[41]).

Another open-access network example is Sunet, a non-profit municipality-owned fibre network that connects 55 villages in rural western Finland. Sunet is used by a variety of private-sector service providers to offer connectivity packages to consumers. Sunet however does not charge for this access, opting to bill consumers directly a fixed fee for the network's maintenance. This lowers the barrier to entry for service providers and encourages greater competition.

These projects are often made possible through a mix of streamlined regulatory approvals at the local level (which reduces costs), voluntary work contributed by local residents, and with funding support from the government. In the case of Sunet, a portion of this funding was in the form of a bank loan guaranteed by the local municipalities, coupled with a contribution from the national government (FTTH Council, 2013[45]).

United States: Dakota Carrier Network

North Dakota in the United States is a highly rural and sparsely populated state with a density of just 4.1 persons per square kilometre. Out of the 50 states plus Puerto Rico and the District of Columbia, North Dakota ranks 49th in population density. Despite this, 76% of rural residents have access to gigabit speed fibre connectivity (FCC, 2020[46]), a level that far exceeds the current average level of fibre provision in both rural (15%) and urban (23%) areas nationwide (as of June 2020). This success is largely the result of a consortium of small, independent rural companies and co-operatives that came together in 1996 to purchase the 68 rural exchanges of the incumbent telephone company. In doing so, these small organisations formed the Dakota Carrier Network (DCN), a state-wide umbrella organisation that covers 90% of the state's land area and 85% of its population (Sousa and Herman, 2012[47]). The development of the DCN's fibre network received USD 10.8 million in federal funding support through the Broadband Technology Opportunities Programme (BTOP). The DCN also enhanced e-health in the state by deploying a dedicated 10 Gbps health care network to over 200 hospitals, clinics, and other health care providers to enable telemedicine, tele-radiology, tele-pharmacy, and electronic health information exchange (NTIA[48]).

United Kingdom: B4RN

Broadband for the Rural North (B4RN) is a non-profit community benefit society that operates a broadband network dedicated towards providing fibre to the home/premises in North West England. B4RN offers 1 Gbps symmetrical fibre broadband to every property in their coverage area. Subscribers are charged an initial GBP 150 installation cost (USD 213) then GBP 30 (USD 42) per month for their service. B4RN supports public services and community development in its region by offering free connections to religious institutions and discounted access to schools (B4RN[49]). Anyone who hosts one of their nodes on their land is given free service for life. Like the community organisations in Sweden and Finland, B4RN relies heavily on voluntary support from the community. It also raises money from investors and through crowd-sourced bond issues. When a new community on the edge of the existing coverage area wishes to be connected, B4RN asks them to raise investment and gain support from local volunteers and landowners. B4RN has received some government support for its network development via the Gigabit Broadband Voucher Scheme.

Iceland: Reykjavik Fibre Network

Iceland is among the top ten OECD countries in terms of share of fibre over total fixed broadband subscriptions. This is partially due to the municipally owned Reykjavik Fibre Network (known locally as Gagnaveita Reykjavikur). The fibre network has been developed by Reykjavik Energy, a for-profit utility that is owned by the Icelandic capital's municipal government. The utility provides electricity, water and waste-water treatment services in addition to fibre connectivity. Though the network began in the capital city, it has since been expanded to neighbouring regions and is continuing to expand.

The network is based on a wholesale open access model, with subscribers able to select between multiple providers for the services they receive. The construction of the municipally owned network seems not to have displaced the private sector; Iceland's major telecommunication company continues to own and build its own network in competition with the Reykjavik Fibre Network. To minimise disruption associated with construction (trench digging, road closures, etc.), the private and public network builders signed a co-operation agreement in 2018 such that whenever one of them installs a new section of fibre, it will install two independent lines in the trench at the same time, so that the ground need only be dug up once (Iceland Competition Authority, 2018[50]). Combined, these two fibre networks now connect more than 120 000 Icelandic homes, 82% of all homes.

While the Reykjavik Fibre Network is being built by Reykjavik Energy on a commercial basis, in the most remote areas of the country some national government subsidies have been made available to connect outlying premises. This funding, through the Iceland Connected to Light initiative is provided to municipal governments to co-fund their network development activities. Iceland considers local government participation vital to bringing fibre networks to rural areas. Three project application rounds took place between 2016 and 2019, each distributing ISK 450 million (USD 3.6 million) with the objective of connecting up to 6 000 premises.

Addressing the "last mile" challenge in rural and remote areas

58. Rural and remote areas have their unique "last mile" challenges due to their distance to core network facilities, making it more costly to deploy infrastructure in areas that, many times, are not commercially attractive. In particular, providing "last mile" fixed broadband connections to individual homes and business premises can present a particularly challenging set of circumstances in some regions. For a remote farm house or cottage, for example, it might involve laying fibre over potentially challenging terrain for the marginal benefit of just one additional potential subscriber. A variety of policy measures and technological solutions may be deployed to address this challenge.

59. The further fibre is deployed in the so-called "middle mile", which provides backhaul, the more options are opened up for either fixed technologies (fibre and copper) or wireless technologies to address the "last mile" connection to the end-user.[6] In addition, by bringing fibre physically closer to the end user, Internet speed increases across all fixed or mobile access technologies (OECD, 2019[51]). However, deployment costs of fibre are much higher in sparsely populated areas than in urban ones. As such, state aid can be used to offset these differences, where needed. In addition, in these areas commercially "unattractive" areas, local interest groups and initiatives, such as community networks, can help both lower costs and increase revenues given their knowledge of local conditions.

60. The challenges for mobile networks are somewhat different. Achieving last mile connectivity with mobile networks tends to be less problematic, since civil works (e.g. digging trenches) are not required to reach each individual house or each individual user (which is reached via spectrum). Mobile coverage is for this reason much more extensive than fixed worldwide. For mobile, the economic challenges often relate instead to ensuring sufficient backhaul capabilities to the mobile cell sites, as well as efficient spectrum management.

61. New technological solutions such as fixed wireless access (FWA) can help mitigate the "last-mile" challenges in rural and remote areas by using spectrum to reach the end-user. While the large majority of OECD countries currently conceive mobile and fixed communication services as complementary rather than substitutes, fixed wireless access (FWA) is a technology evolving to provide higher broadband speeds, and in some circumstances, may help bridge connectivity gaps in rural areas. An example is provided in Box 9.

Box 9. Republic of Ireland: broadband connection points combined with fixed wireless access

The construction of Ireland's fibre network through its National Broadband Ireland (NBI) public-private partnership is expected to take up to seven years, meaning that for some areas this advanced connectivity remains a long way off. Recognising this, Ireland's broadband plan includes interim measures that will use alternative technologies to provide service more quickly in those areas not yet hooked up to fibre. Through the designation of 300 broadband connection points (BCPs), the government and NBI are working to bring connectivity to rural and remote regions within the first 12 months of the plan using fixed wireless connections. BCPs are located in buildings such as community centres and sports clubs. These facilities are being provided with a connection of up to 150 Mbps as a temporary measure until the fibre connectivity arrives in the community. BCPs are making that connectivity freely available to the public onsite and some locations also have additional facilities, such as hot-desking, and may be used as hubs to support local economic and social development initiatives, including digital service delivery. The intent is that these will form an important element of the local digital strategy developed by local authorities to increase adoption and usage of digital technologies by businesses and communities.

Rural hubs like Ireland's BCPs have been used with some success in other countries, including France and the United Kingdom, where they are similarly used not only to provide connectivity, but to combine that with training and support to develop rural skillsets and foster the uptake of digital tools by local firms and residents (ENRD, 2017[52]).

Coverage obligations in spectrum assignment procedures

62. When designing spectrum assignment procedures in G20 countries, policy makers take into account policy objectives such as increasing coverage of communication networks and enhancing competition in mobile markets. Coverage obligations in auctions have proven an effective tool used in G20 countries to extend mobile broadband coverage in rural and remote areas. However, the extent of coverage obligations should not impede certain actors from bidding in the auction (OECD, 2019[53]).

63. In some cases, countries have included obligations to provide connectivity to specific premises, such as schools or highways, and to apply special rates, provide free services for low-income citizens or to provide terminals for schools within spectrum licences. However, setting coverage obligations demands careful analysis. Lax coverage obligations may waste the opportunities to ensure mobile broadband access in areas where there are not enough economic incentives to deploy network infrastructure. On the other hand, obligations that provide for extensive geographical coverage in too short a time may impose an excessive burden on an operator. The usual practice is to impose the same obligations for all the mobile network operators in a country with similar licenses, while possibly allowing any new entrants more time to fulfil obligations (OECD, 2018[3]).

64. Spectrum assignment procedures (i.e. auctions or comparative selection processes) in OECD countries from 2016-2019 have frequently included coverage obligations. During this period, out of the approximately 35 spectrum auctions conducted, 16 included coverage obligations when considering all frequency bands. Ten of these auctions pertained to low frequency spectrum (i.e. lower than 1 GHz), which is a spectrum band that is particularly suitable for extending coverage in rural areas. Seven out of these ten procedures included coverage obligations.

65. In Germany, the June 2019 auction for spectrum licences of the 2.1 GHz and 3.6 GHz bands included coverage obligations of 98% of all households per federal state with 100 Mbps per antenna sector by the end of 2022. It also included coverage obligations of all transport ways (motorways, main roads, waterways, railways) by the end of 2022 or 2024. The assignment holders may use their entire spectrum holdings to meet the coverage obligation and are not restricted to use only the frequency blocks acquired in this auction (BNetza, 2018[54]). In 2011, during the 800 MHz auction, Spain imposed obligations on operators to jointly cover 90% of the villages with fewer than 5 000 inhabitants at 30 Mbps (Government of Spain, 2018[55]).

66. Brazil has also included rural coverage obligations in spectrum auctions as a prerequisite to participate in the bidding process for over ten years, and they have proven a successful tool to foster network deployment around different areas in the country. For example, the 3G spectrum auctions of 2007 and 2010 included obligations to expand 3G coverage in the country. The 2012 auction established coverage commitments with 4G networks, and included expansion of fixed telephony and broadband services with minimum connection speeds of 1 Mbps in rural communities, where rural schools would be

covered and serviced free of charge. Coverage was defined as at least 80% of the area covered within 30 km from the municipality head. According to communication regulator in Brazil, Anatel, the auctions' coverage obligations have been one of several factors leading to an increase of mobile broadband in the country. In 2009, the year that marks the beginning of the commitment schedule linked to auctions, 33% of municipalities did not have any mobile network present. Moreover, only 3% had presence of 3G networks. By 2016, 74% of municipalities had presence of 3G networks. By the end of 2019, 100% of Brazilian municipalities had the presence of at least one 3G network. Backhaul connectivity also increased for municipalities over 2016-19 from 57% to 70% (OECD, 2020[56]).

Concluding remarks

67. Reliable connectivity is fundamental for the digital transformation, facilitating interactions between people, organisations and machines. The COVID-19 health emergency has further accentuated the awareness of how availability, resilience and capability of broadband networks are becoming even more critical to ensure an inclusive society as more and more activities are conducted in a remote manner. In a sense, COVID-19 and the transition to remote work has been a "turning point" in the push for connectivity in many countries, with businesses, society and policy makers realising the urgent need to act now.

68. To help close digital divides, people need access to *high-quality* communication networks and services at competitive prices, regardless of where they live. Territorial gaps in GDP per-capita between rural and urban places across the G20 have been increasing since the 2008 Global Financial Crisis and are expected to increase further with the COVID-19 pandemic. Providing affordable access to high-quality communication networks is a necessary part of the solution in closing those gaps and preparing rural places for the future. The way in which policies and regulations are elaborated has implications on how governments finance the bridging of the digital divide. Policies and regulations that foster competition, promote investment in fixed and mobile networks, and reduce barriers to infrastructure deployment have been extremely effective in boosting connectivity in G20 countries and do not require public funding.

69. Where private funding is not sufficient, some initiatives to bridge connectivity divides in rural and remote areas may require government financing, while others focus on public management that can reduce costs and increase coverage. It has to be noted that G20 economies are at different network and financial development levels. Gaps exist between countries with regard to high-quality network deployment, which are due to multiple factors such as the differences in geographies, purchasing power or level of competition. These differences are paralleled by differences in access to capital and fiscal space. For some G20 economies, Multilateral Development Banks (MDBs) therefore may play a role in complementing private and public funding to boost communication infrastructure deployment. To achieve this goal and given the importance of connectivity and its positive spill-over effects in all sectors of the economy, this would require that MDBs include the extension of connectivity in their funding priority areas.

70. In addition to promoting market forces and reducing deployment costs, some of the initiatives to bridge connectivity gaps may include demand aggregation models, building on local knowledge and initiatives through community networks, using coverage obligations in spectrum auctions as well as subsidising national and rural broadband networks, using general revenues, specific funds or carrying out competitive tenders to foster deployment in rural areas.

71. Disparities in the level of connectivity determine whether and how countries, companies and citizens participate in the distance economy and society. The challenge ahead consists of bridging digital divides within and across countries, namely, by increasing the quality of communication infrastructure and ensuring the resilience of communication networks. While private investment is typically the largest source of investment in communication infrastructures, the public sector has a large role to play both in promoting a domestic enabling environment for investment, as well by the use of alternative models to fill financing gaps in rural and remote areas. This report explored policies to foster financing and improve investment

opportunities to extend high-level connectivity and bridge digital divides, as well as recommending public measures in cases where private financing is not sufficient. Besides fostering access, further digital divides issues need to be overcome. Countries have important roles to improve digital skills and literacy across the G20.

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Notes

[1] For the United States, the speed threshold is 25 Mbps, and has uses percentage of population coverage rather than percentage of households covered.

[2] This is a simple average of the deviations in actual download speeds experienced in rural areas with respect to national average download speeds, in G20 and EU countries (43 countries in total). It is not weighted for the population or territory covered. It is not representative of the population, but rather the average experiences on a country level.

[3] OECD's research for the past two decades has shown that the liberalisation of the communication sector has brought many benefits in terms of increasing the affordability, availability and quality of communication services.

[4] The authors found that the quality-adjusted price index in France decreased by about 51% as compared to a decline in average prices without quality adjustment of 8.9% between May 2011 and December 2014.

[5] The National Telecommunication Infrastructure Information system (Sistema Nacional de Información de Infraestructura, SNII) was created by the approval of IFT's board of the "Guidelines for the delivery, registration and consultation of information to build the National Infrastructure Information System". These guidelines aimed at creating the conditions that would allow identifying the location of the infrastructure used for the provision of telecommunication and broadcasting services to promote their deployment under competitive conditions. See https://www.dof.gob.mx/nota_detalle.php?codigo=5576710&fecha=28/10/2019

[6] While fixed network operators have different timelines and strategies for taking fibre to the premises, node or a distribution point, all operators, whether cable or telecommunication companies, are deploying fibre closer to their customers. Fixed operators can deploy fibre to the premises (FTTP) or to some point in a network such as a cabinet (FTTC) or Node (FTTN) from which copper or other technologies can be used for the final connection (e.g. final 300 metres) (OECD, 2018[3]).