Mobile Strategy Review - International Case Studies

(Final External Report)

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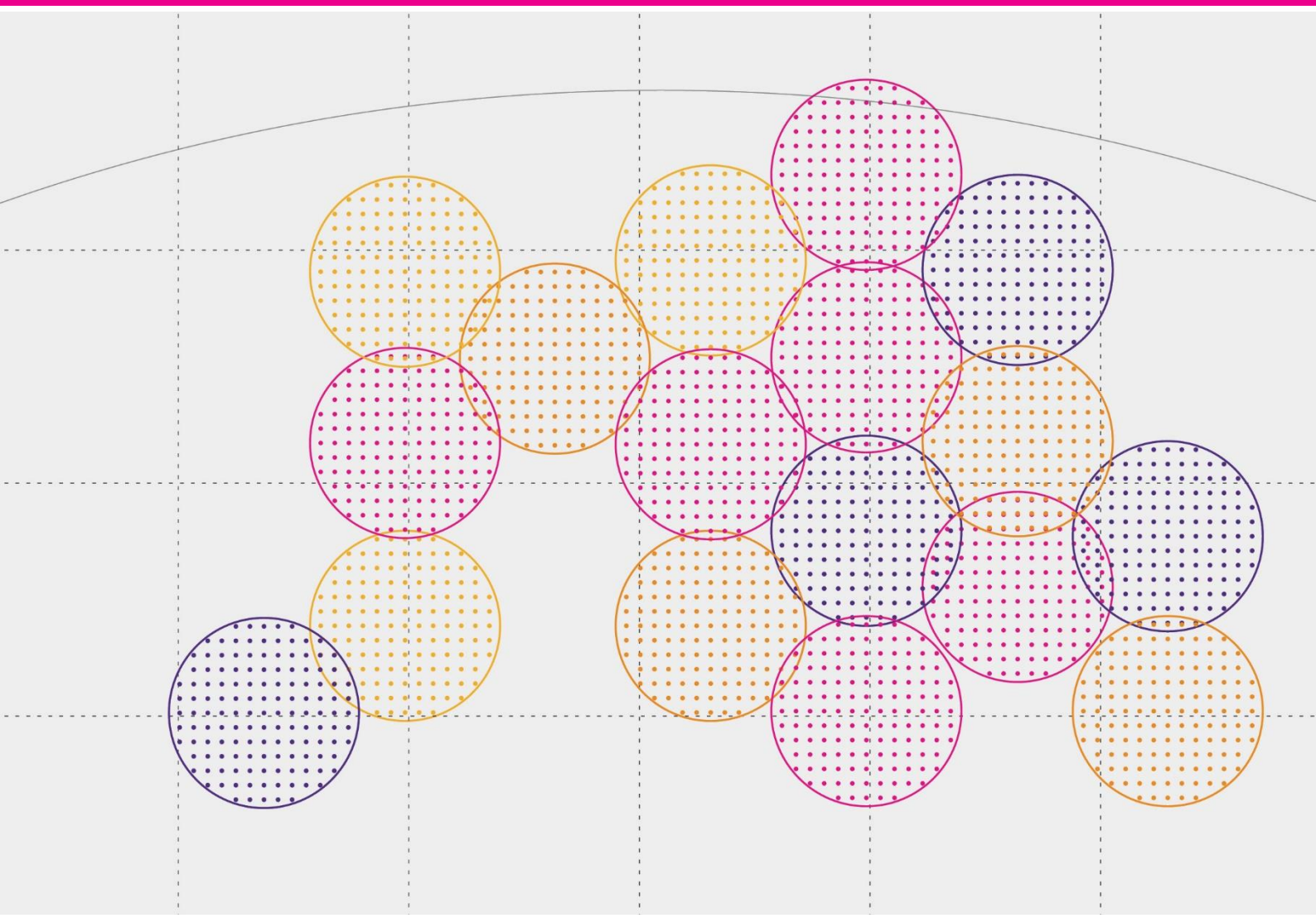

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About Plum

Plum is a leading independent consulting firm, focused on the telecommunications, media, technology, and adjacent sectors. We apply extensive industry knowledge, consulting experience, and rigorous analysis to address challenges and opportunities across regulatory, radio spectrum, economic, commercial, and technology.

About this study

This research study is to support Ofcom in the evidence gathering phase of its Mobile Strategy Review. This study presents the research and analysis of mobile sectors in other markets, with particular focus on those that deliver high-quality networks, greater fixed-mobile convergence, and the increasing influence of tech giants.

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Executive Summary

Introduction

This research study carried out by Plum Consulting (Plum) for Ofcom is to support the evidence gathering in phase one of Ofcom's mobile strategy review.[1] The mobile strategy review will develop a clear regulatory framework against which Ofcom will make future regulatory decisions. A key input to the framework is to develop a clear understanding of market developments. The research and analysis in this study focuses on international developments in mobile markets that perform better than the UK. In particular it considers delivery of High Quality Networks (HQN), greater Fixed-Mobile Convergence (FMC), and the increasing influence of tech giants.

- For HQN, the report considers the factors that support high quality user experience through comparison of selected markets (case studies).
- For FMC, which is considered primarily at retail level, and greater fixed-mobile substitution (FMS), the report considers the market conditions that lead to these outcomes.
- For the influence of tech giants, the report considers how developments involving these players are impacting across different points of the mobile supply chain.

The overall objective of the research is to perform an in-depth comparison of the UK's mobile sector with the developments of the international mobile markets. This provides information on the drivers and implications from these other markets that may be relevant for Ofcom to consider in the UK context.

The study was conducted mainly in August to October 2021 through desk research, and the report provides a snapshot of market and policy environments and relevant issues at the time of writing. The research of HQN provision and FMC/FMS is predominantly focused on international case studies, whereas the research for the influence of tech giants reflects the mobile supply chain with relevant international examples incorporated throughout. A full gap analysis or assessment of the UK position is beyond the scope of this study, but we have included relevant considerations that apply to the mobile market in the UK. The views expressed in this report are solely those of the authors. They are informed by the findings of the research carried out by the study team and their previous sector knowledge and experience.

An overview of the study findings are provided in the following sections.

Delivery of high quality networks

To examine mobile networks that support high quality user experience, we assess network performance (in terms of coverage and connection speeds) and user experience in Finland, Japan, Norway and Taiwan. The choice of markets reflects the different measures of quality (e.g. network speeds, coverage or user experience) that may be considered.

[1] Ofcom, 11 May 2021, Mobile strategy: Terms of reference. Available at: https://www.ofcom.org.uk/phones-telecoms-and-internet/information-for-industry/policy/mobile-strategy

Defining HQN

At the fundamental level the quality of mobile networks can be considered from the technical perspective in terms of network performance or from the consumer perspective in terms of user experience. However, the complexity of today's communications networks means there are many factors at the network level and along the value chain, e.g. the device, hardware, infrastructure, service and applications, that can impact on quality.

Network quality is commonly defined in the following ways:

- **Quality of Experience (QoE)** – overall performance at the services / application level from a user perspective. QoE focuses on the entire service experience and includes the whole path from user to user including the end-user expectation, perception and context of use.

- **Quality of Service (QoS)** – network performance at the bit / packet level. QoS typically concerns the network and terminal equipment up to the user interface, though it can also be narrower in scope taking account of just the access and core network excluding terminal performance.

The science of measurement of network quality is evolving. There is a gap between parameters used to assess network performance, which has focused heavily on data speeds in recent years, and those that deliver good network quality performance. The typical measures of QoS used by national regulators are shown in Figure S.1.

Figure S.1: Most widely used QoS indicators

Category	Indicators
Internet – fixed and mobile	Data transfer speed (maximum, minimum, typical); web page load time; latency; jitter; packet loss rate
Voice	Call set-up time; unsuccessful call rate; speech transmission quality; response time for calls to the operator; customer service and directory assistance
Mobile	Network availability; probability of successful connection in an area covered by the network; dropped call ratio
Customer service	Time between request for service and start of service; fault frequency; time to troubleshoot and eliminate faults; frequency of complaints about billing
Emergency calls	Total number of 112 calls per year; 112 calls as a percentage of total emergency calls; percentage of false calls; average time to answer; percentage of calls answered within 10 seconds; call abandon rate; average time needed for operator to receive caller's location

Source: Stiftelsen IMIT study for the European Commission.

MNOs are increasingly developing their assessment of QoE and QoS. Examples of other parameters that could be considered include latency, jitter, packet loss performance, end to end service performance. Cell dimensioning and overhead allowances in traffic planning are also important to ensure that cells can deliver the capacity required for simultaneous traffic demands on a cell.

Coverage is also key to the delivery of quality networks, although much has already been done to improve mobile coverage. However, the combination of coverage and capacity at a location is key for assessing the quality of networks. At present, these metrics tend not to be publicly reported by MNOs and regulators.

Plum analysis of high quality networks relies on publicly available and comparable indicators reported by organisations including GSMA Intelligence and Opensignal as well as those published by national regulators.[2] Specifically, we consider national and operator-specific indicators for population coverage of 4G networks, 4G network availability (a measure that indicates the percentage of time that users can access the 4G network, published by Opensignal), and 4G network download and upload speeds. This is supplemented by operator-specific metrics for user experience of mobile video, gaming and OTT voice apps collected by Opensignal.

Key HQN themes and observations

Each HQN case study is a high performer with regard to a different quality metric and service price differentials are observed between markets. High quality of service and observed differences across the HQN markets have primarily been driven by a combination of market factors (including competitive dynamics) and regulatory policy (including spectrum policy). In the HQN markets, the operators tend to have established market shares and primarily compete on price and type of data packages. Network speeds and coverage tend to be secondary aspects of competition. The key themes and observations from the HQN markets are as follows.

- **In terms of quality metrics,** Japan's MNOs rank as leading operators for mobile user experience globally, Norway has the highest average network speeds, and both Finland and Taiwan report high levels of 5G population coverage whilst supporting some of the highest levels of mobile data consumption globally.

- **Drivers of HQN**: There are a wide variation of factors that affect HQN deployment. The most common of these drivers, which we observe in at least two HQN markets, are as follows.

  - **Timely spectrum availability**: The ample supply of spectrum is a key component for high quality networks. The last 10 years has been characterised by rapid growth in mobile data traffic and this trend is likely to continue with the evolution of mobile networks from 4G to 5G and beyond. MNOs need access to a combination of low, mid and high frequency bands[3] to fully serve 5G use cases, and to meet existing requirements to improve enhanced mobile broadband (eMBB) coverage and quality of service in rural areas. Timely spectrum release is important to ensure MNOs have sufficient spectrum to support network capacity and coverage demands, and particularly to encourage investment certainty and deployment of 5G services.

  - **Spectrum licence obligations**: The coverage obligations imposed in HQN markets have tended to focus on achieving eMBB coverage across the population. More recently, there has been a shift towards ensuring better geographical coverage (e.g., coverage of key transport routes or rural premises) in order to promote ubiquitous access to eMBB services and some spectrum licences require provision for emergency services.

  - **Regular monitoring of network quality**: There are different approaches to monitoring QoS across the selected HQN markets. The requirement for MNOs to provide reports of network performance applies in each HQN market in some form though the specific requirements may not be publicly known. Further, the regulators publish information on MNOs' network performance in all but Norway. Again, there are different approaches to publishing this information such as network performance metrics included in the regulator's annual statistical publications or use within consumer tools (further discussed below).

[2] Where possible, we have sought to use one source for each metric to ensure that the measurement method and reporting interval are consistent across the high quality network case studies.
[3] Low bands are those below 1 GHz, mid-bands are typically between 1 to 6 GHz and high-bands refer to mm-wave frequencies above 24 GHz.

- **Financial incentives**: To support deployment of high quality mobile networks, measures targeting rapid 5G rollout or rural broadband provision are common. However, use of financial incentives only partially explain the higher 5G coverage. Taiwan has achieved the highest coverage of all HQN markets discussed. Whilst its 5G network deployment subsidy and associated milestones have supported rapid deployment of 5G, the subsidy was partly introduced to offset high spectrum auction prices. 5G tax incentives have been introduced in Japan, and spectrum licence discounts were offered to MNOs taking on coverage obligations in Norway. No financial incentives were offered in Finland but the regulator has permitted extensive infrastructure sharing by MNOs.

There are also a number of other factors and considerations that can influence network quality and user experience including:

- **Market structure**: In general a higher number of MNOs reduces the amount of spectrum available for each MNO which could lead to sub-optimal outcomes for consumers in terms of higher network costs or lower service quality. The selected HQN markets include between three to five players. In Taiwan, a five-player market with intense retail competition, we observe spectrum constraints and sub-optimal allocations. This could have negatively impacted on network quality if it were not for spectrum refarming to more efficient 4G/5G technologies by MNOs and introduction of spectrum and network sharing arrangements for 5G. Whilst a more competitive market structure may deliver better price competition, this should be balanced against potential impact on spectrum availability affecting QoS and network deployment costs affecting price level.

- **Geography and network deployment**: Network deployment and costs are heavily influenced by the specific geographical characteristics of each market. While commercial arrangements among operators can help overcome some of these challenges (such as network sharing in rural areas), in most markets there tend to be some form of policy or regulatory intervention aimed at ensuring adequate network coverage and level of service quality. As such, the use and design of geographical and population coverage obligations can have a more critical impact on HQN provision in markets with more rural, more dispersed populations.

- **Technology aspects**: Improving spectral efficiency (in terms of data rate that can be transmitted over a given bandwidth) is key to delivering high quality networks. For mobile networks, this depends on technology deployed, the associated equipment specifications and network configuration. The phasing out of legacy 2G and 3G networks and spectrum refarming to support the most advanced technologies is an important strategy for MNOs to meet the demands of growing mobile data consumption. Other technical options, such as spectrum sharing and network segmentation through slicing, can boost spectrum utilisation and network quality.

However, the experiences and factors driving high quality provision vary significantly across the HQN markets.

- **In Finland,** a stable market structure with timely release of ample spectrum and extensive network and spectrum sharing across rural areas are important factors. The requirements on MNOs to provide indoor coverage as part of spectrum licensing is another factor.

- **In Japan,** the highly planned, supply-focused approach to spectrum management involves tight regulatory oversight of technologies deployed and network performance. This has ensured early deployment of advanced network protocols and high quality.

- **In Norway,** regulatory interventions such as Significant Market Power (SMP) obligations and merger remedies have been important in facilitating the growth of a credible third MNO to ensure an adequate level of competition at the retail level. In addition, spectrum obligations associated with

spectrum licence discounts have supported mobile broadband coverage across rural areas and key transport routes.

- **In Taiwan,** intense competition has led to low prices and high usage, but MNOs have managed to sustain high quality with denser networks and by re-farming spectrum following the phase out of 2G and 3G services. Recent changes to introduce more flexibility for network and spectrum sharing by MNOs aim to address concerns over 5G deployment costs and to safeguard consumers by maintaining a competitive 5G environment.

- **In terms of price level,** we find no clear evidence that higher quality network provision is associated with higher retail prices for mobile services given the significant variation in price levels across the HQN markets. It should be noted that international price comparisons (for example, by ITU or OECD and Teligen) have primarily compared basket prices for tariffs with similar voice and data allowances and do not account for differences in network quality (e.g., connection speed offered as part of the tariff or cross-country differences in QoS).

  In the case of Taiwan and Japan, price competition (or lack thereof) has been a driving factor in observed price levels. Prices in Japan are significantly higher than other HQN markets – approximately double the price for a lower usage basket (0.5 GB, 30 calls). In contrast, prices in Finland and Taiwan are significantly lower and tend to be in a similar range to the UK.

  Whilst we observe an inverse relationship between prices and usage (e.g., highest prices and lowest usage in Japan, lower prices and higher usage in Finland and Taiwan), it is not possible to assess the direction of causality within the limits of this study. In Japan, for example, higher prices and the presence of high quality fixed connectivity may have contributed to lower mobile data usage though we find no evidence to support this conclusion.[4] In contrast, intensive competition between operators in Taiwan has resulted in low prices though affordability is not the only factor for higher mobile data usage – high levels of fixed-mobile substitution are observed similar to Finland.

  In some HQN markets operators are differentiating prices according to quality. Operators in Finland and the leading operator in Norway are differentiating packages and price levels by connection speeds whereas other operators in Norway and Taiwan advertise higher connection speeds for larger data allowances.

- **In terms of consumer awareness,** evidence regarding consumers ability to identify and choose based on different quality of service varies significantly. Whilst some operators in HQN markets report connection speeds, consumers in general have limited ability to exercise choice. With the exception of Finland, connection speeds are tied to allowances and are not reported in Japan. In Taiwan, we note that actual connection speeds are substantially lower than those advertised.

  Each regulator monitors network quality, though the number of quality measures (primarily coverage, speeds and network availability) vary as does the approach. For example, the Finnish MNOs each provide coverage maps for mobile and fixed services on their retail websites though the regulator is also developing an independent crowdsourcing tool accessible to consumers. In Taiwan network coverage and quality information is published by the regulator and by MNOs. MNOs in Norway are required to submit performance information to the regulator though the full extent of this is not publicly reported. Nkom publishes maps on the availability of broadband services by speed and technology (e.g., mobile, FWA, other fixed technologies). In our review, however, we have found no evidence to suggest whether consumers in any of the HQN markets access this information and, if so, how this informs their choice.

[4] For example, information on mobile tariffs is limited to price level for representative usage baskets (allowances) and does not reflect uptake of cheaper lower-usage versus more expensive higher-usage packages. Similarly, there is limited evidence to illustrate the extent of Wi-Fi offloading.

Figure S.2 summarises the key findings of the HQN case studies and further highlights key policy and market drivers resulting in provision of high quality networks.

Figure S.2: Key findings from HQN case studies

Market	Mobile connectivity and use of mobile services	Drivers of HQN?	Consumer awareness and choice over QoS
UK	• 5G launched in 2019, population coverage at 30% (Q2 2021). • Mid-low mobile data usage, 5.3 GB/user/month.	• **Coverage obligations:** Proposed obligations for 5G 700 MHz and 3.5 GHz auction removed due to Shared Rural Network. Geographic and population coverage obligations attached to previous 800 MHz/2100 MHz and 900/1800 MHz assignments. • **Network sharing:** Shared Rural Network initiative between UK Gov and four MNOs to extend 4G coverage nationwide. • **Spectrum sharing & local licensing:** Arrangements for 5G verticals and private networks. • **NGA support:** UK Gov funding for NGA rollout focused on fixed connectivity rather than MBB. • **Switch-off:** No 2G/3G switch off – press reports indicate mid-late 2020s.	• **Speeds in tariff offer?** Network speeds are not a common feature of tariffs. Where advertised, offer best connection available or 5G superfast speeds for premium services. • **Public QoS reporting**: Ofcom report on MNOs coverage (indoor/outdoor, 4G/no 4G) across UK postcodes via its Broadband and Mobile Checker tool.
Finland	• 5G launched in 2019, population coverage at 65% (Q2 2021). • Very high data usage 30.99 GB/user/month. • Large proportion MBB-only home subscribers driven by unlimited data packages and lower FBB penetration.	• **Speed as a competitive dimension:** advertised in tariffs. • **Timely spectrum:** Early access to key spectrum bands. • **Network sharing:** Between Telia and DNA to support rural mobile and 5G coverage. • **Coverage obligations:** Sub-1 GHz spectrum licence includes obligation to provide indoor coverage. • **Local licensing:** Broader support for local 4G/5G networks through light licensing. • **Reduced regulatory barriers**: No licence needed for construction of 5G base stations.	• **Speeds in tariff offer?** Network speeds are a common feature of tariffs with consumers able to select connection speed. • **Public QoS reporting**: Traficom plans to introduce independent speed/QoS monitoring and comparison site. Each MNO currently hosts coverage maps for own network on their websites.

Market	Mobile connectivity and use of mobile services	Drivers of HQN?	Consumer awareness and choice over QoS
Japan	• 5G launched in 2020, population coverage at 48% (Q2 2021). • Mid-low mobile data usage, 5.05 GB/user/month.	• **Government intervention and regulator policy:** Managed approach to HQN technology and spectrum usage. • **NRA QoS monitoring:** MIC monitors spectrum usage and efficiency, including MNO rollout and deployment of advanced technology protocols. • **Timely spectrum:** Early access to key spectrum bands, though not always harmonised globally. • **Financial incentives:** Tax incentives introduced to support 5G investments. • **NGA support:** Extensive fibre connectivity for backhaul and subscribers Wi-Fi offloading. • **Switch-off:** 2G switched off since 2012.	• **Speeds in tariff offer?** Network speeds not reported as part of MNO tariff offers. • **Public QoS reporting**: QoS is monitored, and network performance metrics published as part of MIC's statistical publications. However, there does not appear to be a consumer tool to compare MNO networks. • All 4 MNOs amongst top international HQN performers (Opensignal).
Norway	• 5G launched in 2020, population coverage at 33% (Q2 2021). • Average data usage 7.3 GB/user/month.	• **Government and regulatory interventions** to facilitate a third MNO and promote effective competition to two main MNOs (including SMP and merger remedies). • **NRA QoS monitoring:** Operator obligations related to measuring and notifying Nkom of network quality. • **Coverage obligations & financial incentives:** Auction process includes financial incentives and spectrum fee discounts for taking on obligations to improve quality of rural broadband in recent 2021 5G award (2.6 GHz and 3.5 GHz) and coverage of transport routes in the 2019 award (700 MHz and 2100 MHz). • **Switch-off:** 3G switch-off planned (2021).	• **Speeds in tariff offer?** Network speeds advertised as part of packages, though only Telenor offer their unlimited data subscribers' choice of connection speed. • **Public QoS reporting**: MNOs subject to QoS reporting obligation and monitoring by Nkom, though detailed figures are not publicly available. Nkom publishes annual broadband coverage map showing speed and technology type (mobile, FWA, etc). • MNOs offer similar coverage though download speeds differ.

Market	Mobile connectivity and use of mobile services	Drivers of HQN?	Consumer awareness and choice over QoS
Taiwan	• 5G launched in 2020, population coverage at 74% (Q2 2021) • Very high data usage 22.4 GB/user/month. • Majority of users are on unlimited data plans.	• **Quality driven by competition:** High level of market competition with 5 MNOs. • **Network and spectrum sharing:** Updated regulations to facilitate 5G network and spectrum sharing. • **Financial incentives:** Government financial support, including 4G demand-side initiatives and 5G rollout subsidies for operators. • **Switch-off:** Spectrum constraints has led to re-farming of 2G and 3G spectrum. 2G switched off (2017), 3G only for circuit switched fallback (CSFB) (2018).	• **Speeds in tariff offer?** Network speeds advertised though connection speeds are most commonly stated with regards to throttled speed once initial data allowance exceeded. • **Public QoS reporting**: MNOs required to publish information on signal coverage and reception quality, and Wi-Fi hotspots. Research on network performance is published annually.

High quality networks and the UK

On the whole, the UK's performance appears to be slightly below those observed in the selected HQN markets for publicly available metrics.[5] While there are variations across the selected markets based on the available network quality and experience indicators, the UK currently trails in terms of:

- Network speeds (download/upload) and network availability.
- 5G coverage by population is lower than other HQN markets, according to data from GSMA Intelligence.
- Mobile user experience in terms of video, gaming and voice app experience.

There is limited information on cross-country mobile prices although a European Commission study indicated that as of 2019 UK prices tend to be lower than the EU average and similar to levels in Finland which is the lowest among the selected markets. This pricing analysis, however, relies upon the lowest-price offer and does not account for difference in quality of service.

Mobile data usage in the UK (5.3 GB/user/month in 2020) ranks behind the four selected markets and is significantly lower than Finland and Taiwan where popularity of unlimited data plans, consumer habits and fixed-mobile substitution has resulted in very high rates of mobile data consumption. As a detailed comparative analysis of the UK market is outside the scope of this study, it is not possible to identify the extent to which factors such as network quality, user experience, consumer preferences and prices explain the level of mobile data usage in the UK.

The timing of spectrum release in the UK has been slower compared to Finland and Japan (for example, 700 MHz and 3.4-3.8 GHz). Japan leads in terms of the total amount of spectrum assigned for MNOs. Spectrum supply in the UK is on a par with Finland and Norway though there are only three MNOs in each of the two Nordic markets. While Taiwan has the least amount of mobile spectrum assigned among the selected markets,

[5] Based on the GSMA Intelligence's 5G network coverage metric, Opensignal's download and upload speed data, and Opensignal's user experience ratings for mobile gaming, video and voice app experience.

MNOs have managed to cope with high levels of data traffic by deploying denser networks compared to the UK and the other markets.

The UK Shared Rural Network (SRN) is a similar initiative to the Finnish Shared Network (SYV). Both initiatives aim to extend high quality services across rural areas. The SYV is a joint venture between Finland's two smaller operators – Telia and DNA – that involves RAN and spectrum sharing for 2G, 3G and 4G and has been operating since 2014. In early 2021, it was announced that SYV would include 5G with the shared network expanding to cover 62.5% of the area and 28.5% of the population by 2023. In contrast, the UK SRN is a joint programme between UK Government and the four MNOs. It aims to extend 4G mobile coverage across 95% of the UK by the end of the programme, expected in early 2027.[6] No commitments have yet been announced in terms of 5G coverage at the time of writing.

Greater fixed-mobile convergence

In order to assess the drivers of greater FMC, we examined the market for fixed-mobile bundling and consumer impacts in France, the Netherlands, Portugal and Spain. We further extended the HQN case study on Finland to examine the high level of substitution between fixed and mobile broadband (fixed-mobile substitution, FMS).

Defining FMC

FMC can take several forms from network convergence through to convergence at the retail level, delivered through the bundling of retail packages. The focus of analysis for this report is on the latter. Converged offers to customers can take several forms including:

- A package with fixed and mobile service components sold as a single entity and differentiated from separate fixed and mobile subscription packages.
- A subscriber to a fixed or mobile package being able to purchase an additional package, at a discount only available for this purpose, leading to a cheaper combined package but with two contracts.

Similarly, FMS can be considered from both demand-side and supply-side. Demand-side FMS is typically observed at the retail level with residential consumers subscribing to only mobile services for both mobile and at-home internet and voice services, forgoing traditional fixed line services. Supply-side FMS can also refer to provision of at-home internet services through mobile broadband or fixed wireless access (FWA) technologies as opposed to fibre or other fixed line technologies.

Key FMC themes and observations

The key findings on fixed-mobile convergence are:

- **Nature of FMC markets:** In the selected FMC markets, we do not observe mobile-only or fixed-players. The markets tend towards convergence and non-converged operators will replicate fixed-mobile and bundled service offerings through wholesale access (for example, fixed operator Grupo NOWO which has launched two MVNOs) or merging entities (as observed in the Netherlands).
- **Business model**: Fixed-mobile providers tend to use both their own infrastructure and wholesale access to other operators' infrastructure, in order to provide both fixed and mobile retail services. In France and the Netherlands, all MNOs have some fixed infrastructure that they use to provide fixed-mobile services

[6] Shared Rural Network, 2021. Available at: https://srn.org.uk/

and wholesale access regulation ensures smaller players can access larger fixed networks. A similar dynamic is observed in Portugal and Spain, where there has been a greater focus on infrastructure sharing to deliver gigabit-capable broadband and full-fibre networks, as well as availability of a number of independent wholesale networks in some areas.

Furthermore, one of the key commercial advantages relates to pay-TV services, which are offered in bundles and tend to be less substitutable between operators. The inclusion of pay-TV and other entertainment offers is observed in all markets and is a particularly strong driver of bundle uptake (including FMC) in Portugal and Spain.

- **Supply of fixed-mobile bundles**: Fixed-mobile service bundles are common across the markets surveyed, and are usually offered as multi-play packages, including pay-TV in many cases. The markets tend towards converged fixed-mobile operators and non-converged players seek to replicate fixed-mobile and bundled service offerings through wholesale access (e.g., the Portuguese fixed operator Grupo NOWO has two MVNOs) or through mergers and acquisitions (e.g., Netherlands and Spain). In Finland, fixed-mobile bundles are offered by the major players but are not widely advertised as their fixed broadband networks do not cover the whole country, and thus the availability varies across locations and regions.

- **Adoption of fixed-mobile bundles**: Service bundles which include a mobile connection are generally popular – across the five markets surveyed the household take-up of such bundles range from 37% (France) to 66% (Spain).[7] However, there are several differences as follows.

  - In Portugal and Spain, there has been a trend in recent years towards bigger quadruple- and quintuple-play bundles which include fixed, mobile and/or pay-TV services. This reflects the M&A activity involving telecoms operators and cable providers. In these two markets the proportion of households with a service bundle that includes a mobile connection has increased by 10 percentage points or more over the 2017 to 2020 period.

  - In the Netherlands, the opposite trend is observed, as consumers switch from triple-play to simpler fixed-mobile bundles without pay-TV. This is indicative of the growing popularity of online streaming platforms and VoD services which appears to have prompted some households to switch away from traditional pay-TV bundles.

  - In Finland, there is a significant proportion of households who only take up mobile broadband – 36% as of 2019 which is the highest across the EU. Over the 2017-2020 period, households with a bundle that includes a mobile service has declined by 9 percentage points.

- **Pricing**: Fixed-mobile bundles are usually offered at a discount by operators compared to purchasing the equivalent fixed and mobile services individually. However, it is not always the case that consumers get the best deal, in terms of overall price, by opting to buy both fixed and mobile services from the same supplier. In some cases, purchasing the services individually from different providers may be the least costly option. There are many factors that drive the pricing of bundles including consumer preferences, convenience, quality of service, pricing strategy and the type of TV content included in the bundle.

A summary of the key findings from the FMC/FMS case studies is provided in Figure S.3 below.

[7] Note these figures refer to bundles that include a mobile service. It is expected that the majority of these bundles would also include a fixed service. While it is possible that there are bundles comprising a mobile service but not fixed (e.g. a mobile and pay TV bundle), such service bundles are not commonly observed or available in most markets.

Figure S.3: Key findings from FMC/FMS case studies

Market	Take-up of fixed-mobile bundles? Impact on switching?	Business models? Own network or wholesale access?	Commercial advantages of own mobile and fixed networks?
Finland	• Fixed-mobile substitution reflected in high proportion of mobile broadband-only households (36%). • Driven by unlimited data bundles and larger mobile than fixed NGA footprint.	• MNOs operate nationwide and also operate as the main mobile/fixed ISPs. • There is also a patchwork of larger and smaller regional fixed network providers.	• The three MNOs benefit from nationwide operation and ability to benefit from their scale and the consistent scope of retail propositions they can offer. • Regional fixed operators are more driven by local conditions and to some extent may be restricted by differences in wholesale pricing between urban and rural areas.
France	• 37% of French households take mobile services as part of a bundle, and 49% take fixed internet access as part of a bundle. • ARCEP data indicates that, as of March 2021, 30% of France's 70m post-paid SIM cards are coupled with fixed access.	• All 4 MNOs own (or co-own) fibre infrastructures, with significant shares in fixed networks. • Supported by symmetric regulation for FTTP, and access to wholesale or public FTTP networks or Orange's mobile network.	• Orange has largest mobile share but declined over last 10 years. • Notable that Free Mobile has chosen to deploy its own FTTP network.
Netherlands	• 40% of households take mobile services as part of a bundle, and 86% take fixed internet access as part of a bundle. • Fixed-mobile bundles are over a third of bundled subscriptions. • Limited information on switching but observe consumers switching to simpler bundles (fixed-mobile or dual play (2P)).	• Three main MNOs offer fixed broadband services via own networks. • KPN and Ziggo have largest fixed footprints, and KPN must offer wholesale fixed access. Used by T-Mobile and some MVNOs for bundle offers.	• Large number of mergers between fixed and mobile operators seem to indicate advantages of own networks. • Cable/pay-TV important for bundled offers though recent shift to simpler bundles is a likely reflection of increased take-up of OTT SVoD services.
Portugal	• High take-up of bundled services – 50% of households take mobile services as part of a bundle, and 68% take fixed internet access as part of a bundle. • 4P/5P offers account for 50.3% of bundle subscriptions (these bundles include fixed-mobile services).	• Mix of business models. MEO access to Grupo Altice fixed network. NOS has access to own network and agreed to deploy FTTP with rival Vodafone. Also 2 MVNOs from Grupo Apax that offer fixed services (hosted by MEO for mobile and provided by other wholesale access for fixed).	• Some commercial advantage suggested as MEO/Grupo Altice holds the largest shares in fixed and mobile. • Wholesale access provisions allow operators to use other networks. • Pay-TV and other bundled services are important determinants of take-up.

Market	Take-up of fixed-mobile bundles? Impact on switching?	Business models? Own network or wholesale access?	Commercial advantages of own mobile and fixed networks?
Spain	• High take-up of bundled services – 66% of households take mobile services as part of a bundle, and 57% take fixed internet access as part of a bundle. • Fixed-mobile bundles represent 40.9% of all bundle subscriptions in 2020; fixed-mobile with TV is 39.1%.	• Market consolidation means operators each have some of their own fixed and mobile infrastructure. However, government promotion of infrastructure sharing and wholesale access means operators use own network and wholesale access.	• Potentially limited given Government push for shared infrastructure use and fibre-sharing/co-investment between operators.

Fixed-mobile convergence and the UK

The UK is unlike the selected FMC markets, in that there are established mobile operators such as Three and O2 (prior to its merger with Virgin Media), which are predominantly standalone pure-play mobile players.

To date, fixed-mobile bundles are less prevalent in the UK than in the other FMC markets. Ofcom consumer survey data indicates that while 80% of UK adults have purchased two or more communications services from the same provider as part of a bundle in Q1 2021, only 17% of UK adults purchase a combination of fixed and mobile services from the same provider (or 18% of UK mobile users purchase a combination of fixed and mobile services from the same provider).[8] In the European markets examined, communications service bundles which include a mobile service, range from 37% take up in France to 66% in Spain.[9]

One possible explanation is the lower levels of ultrafast broadband coverage in the UK compared to the other FMC markets. As of 2020, household coverage of very high capacity networks[10] is 10% in the UK, compared to over 80% in Portugal, Netherlands and Spain. As mentioned above the wide availability of wholesale broadband services has facilitated higher levels of fixed-mobile adoption in these markets.

In the UK the expansion of fibre broadband, along with technology synergies between 5G and fixed networks, will offer more opportunities for competitive converged service offerings over the coming years. At the same time, the growing popularity of streaming video services, such as Netflix, Amazon Prime Video and Disney+, is diminishing the attractiveness of premium TV bundles. In this regard, the UK is relatively advanced – 60% of UK households were subscribers to video-on-demand services as of Q3 2020, higher than the proportion of pay-TV households (48%).[11] This may increase the attractiveness of simpler service bundles (without TV), and lower barriers to entry for challenger operators, who could seek to target specific market segments through partnerships with wholesale networks and third-party OTT providers.

Increasing influence of tech giants

Tech giants include a variety of businesses ranging from hyperscale providers to larger OTT service providers. Over the past decade, the presence of these players has become much more visible in provision of services to

[8] Ofcom Technology Tracker 2021, 14th January to 31st March 2021. Table 156. Available at https://www.ofcom.org.uk/__data/assets/pdf_file/0015/219102/technology-tracker-2021-data-tables.pdf
[9] European Commission, June 2021, E-Communications in the Single Market. Special Eurobarometer 510. Available at: https://europa.eu/eurobarometer/surveys/detail/2232
[10] This is defined as Fibre-to-the-home (FTTH), Fibre-to-the-building (FTTB) and cable DOCSIS 3.1.
[11] Ofcom, 5 August 2021, Media Nations: UK 2021. Available at: https://www.ofcom.org.uk/__data/assets/pdf_file/0023/222890/media-nations-report-2021.pdf

end users, including those on mobile networks. There are many positives resulting from the presence of tech giants who can deliver solutions to both end users and to mobile operators. Tech giants are well placed to deliver solutions that can drive increased service scope, agility, efficiency and lower costs. However, there have also been concerns raised about tech giants in respect of both market influence and the potential for harms under some conditions. Key to ensuring that the influence of tech giants is beneficial is to create conditions that reduce the risk of more negative consequences of their presence playing out.

Definitions

A variety of terms like hyperscale players are used for tech giants and below are set out some definitions for this report.

Hyperscale: Key hyperscale players are Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure and Alibaba. While there is no clear definition of a hyperscale provider it is usually a business that provides cloud computing, storage and networking on a very large scale. Other players like Facebook and Apple are sometimes also referred to as hyperscale providers, however, they are predominantly retail suppliers (Apple does provide storage to users as part of its retail bundles).

OTT service providers: These players can vary in size from being small to very large (e.g., at the large end Facebook, Apple, Disney). They are businesses that deliver services (e.g., video) to users over an IP network (including mobile). Some very large OTT providers (e.g., Amazon Prime video) might also be considered hyperscale. OTT service providers also encompass a wide range of businesses that deliver services to the enterprise segment (e.g., Salesforce, Oracle).

Another term used is “big tech” and this is generally understood to include a group of companies like Amazon, Apple, Google, Facebook and Microsoft.

Tech giants – key findings

The key findings on tech giants are:

- These players are undoubtably present in the mobile value chain and they are having increasing interaction with both network providers and directly with consumers, much of which is delivering positive results.
- For content and applications there is an increasing level of provision to consumers on mobile devices by OTT service providers.
- Specialist technology and hyperscale providers are already playing a role in provision of mobile network services as network functions are virtualised (e.g., 5G core, Open RAN) and through involvement in Mobile Access Edge Computing (MEC).
- Tech giants (and many other technology providers) are also exploring the potential to supply to Mobile Private Networks (MPNs).

We do not see a near term structural shift, for example the entire network business of MNOs moving to tech giants. However, we do see that tech giants will provide more network and other services to MNOs over the next few years. These services are most likely to comprise, for example, Infrastructure as a Service (IaaS) and Software as a Service (SaaS). Technology suppliers are also providing Network as a Service (NaaS) and Communications Platform as a Service (CPaaS) capability.

So far, the primary users of NaaS are enterprises who do not own (or want to own) a network of their own. Whether tech giants will end up being full NaaS providers to MNOs is difficult to judge at this time, but there is an opportunity for MNOs or other wholesale operators to provide NaaS to MVNOs. Nokia, for example is considering how this might play out and the opportunity exists for tech giants to do likewise.

Where tech giants have ventured into connectivity it has been to drive this from a low base (e.g., in developing markets) and/or to drive more traffic to their services. We do not see any significant evidence that tech giants intend to move into being more general access network providers (although with developments like Open RAN, Mavenir and others, not generally seen as tech giants, will become more visible).

5G MPNs are an interesting and developing field, where the combination of open networks and 5G standalone core on cloud native infrastructure, might open the door (provided suitable spectrum can be obtained) to new enterprise service providers who rely totally on others to provide their networks (e.g., NaaS). While these business models are conceptually possible, concrete examples that show the approach works at scale have yet to emerge. This is a potential opportunity for tech giants (e.g. hyperscalers) and others (e.g. systems integrators).

In the consumer market, Google has gone down the road of becoming an MVNO with Project Fi (now Google Fi). The most capable versions of Fi use specific capabilities in Google's mobile devices, the Android OS and more recently eSIM capability. So far, there have not been similar moves by Apple.

Technology players are also increasing their role in mobile (and other network) back-office functions like OSS/BSS. Taking these functions into the cloud allows for the retirement of expensive legacy systems, integration of OSS/BSS capability across multiple network platforms and can deliver advantages in flexibility and agility to MNOs.

For consumer services, OTT service providers have an increasing affinity with consumers built on content and applications, which limits the ability of MNOs to develop new service revenues by creating these services for themselves. The trend among MNOs is, where possible, to work with these players (e.g., by bundling their services into mobile subscriptions). We expect these trends to continue. However, the increasing share of OTT service provision creates increased dependencies on these suppliers and raises security, resilience and privacy risks, which MNOs are increasingly having to consider. Governments and regulatory authorities are likewise considering these issues.

Regulatory responses

There are multiple drivers for regulatory responses to tech giants including (depending on the type of player):

- Concerns about their ability to exert market power (e.g., on search engines).
- Dealing with illegal or harmful content.
- Security and privacy issues.
- Sovereignty.
- Network resilience.

Many jurisdictions are now considering or acting on these concerns and other policy/regulatory issues, but this needs to be done carefully to ensure that beneficial aspects of the presence of tech giants are not lost. Alignment around regulatory issues is starting to occur but there is little global consistency at present on the approach to regulation of tech giants (partly because these players are international or global in scope, largely

operate in an ex-post environment, face the possibility of multiple approaches from different jurisdictions and partly because of the absence of standards like those that play a key harmonising role in the electronic communications field). They started from a position of self-regulation.

Examples of legislative/regulatory action include measures like GDPR, and the work currently in progress in the European Union on the Digital Markets Act and Digital Services Act. There has also been work in the United States on things like platform monopolies, service switching and portability of on-line data. Regulatory responses in the UK are set out below.

Tech giants and the UK

Tech giants are well established in the UK. More specifically:

- Hyperscale players have a presence in the UK (e.g., Microsoft Azure has been offering services from UK data centres since 2016, as has AWS). They are actively developing their businesses including potential business with MNOs and others in the mobile sector. Examples of hyperscale involvement include:
  - AWS and Vodafone UK with AWS Wavelength, providing MEC services, and
  - O2's partnership with Microsoft Azure for MEC within private 5G networks.
- OTT service providers are similarly well established and have played a key role in the content and applications markets for a considerable time.

Examples of policy and regulatory responses in the UK include:

- Online harms – Online Safety Bill – This is aimed at creating a new regulatory regime to address illegal and harmful content online, with the aim of preventing harm to individuals in the United Kingdom. It:
  - Imposes duties of care in relation to illegal content and content that is harmful to children.
  - Imposes duties on providers in relation to the protection of users' rights for freedom of expression and privacy.
  - Confers powers on Ofcom to oversee and enforce the new regulatory regime.
- The government has also consulted on a new pro-competition regime for digital markets. The Plan for Digital Regulation sets out the government's overall vision for governing digital technologies including new principles to guide design and implement the regulation for digital technologies. Enabling more active innovation is a key driver.

However, at present there are no specific plans to consider new policy or regulation in respect of the role tech giants are likely to play in the provision of mobile services as MNOs upgrade and expand their networks.

1 Introduction

This research study for Ofcom is to support the regulator's evidence gathering in phase one of its mobile strategy review. The mobile strategy review will underpin future regulation and support the delivery of high-quality connectivity and innovation to meet people's future needs.

The research undertaken by Plum focuses on three areas where significant changes have been observed across the mobile value chain. The objective is to situate the UK's mobile sector within a wider international context by taking an in-depth look at developments in other markets relating to:

- **Delivery of high quality networks** that support higher quality user experience. We examine delivery and user experience of high quality networks in Finland, Japan, Norway, and Taiwan. The choice of these markets reflects different measures of quality (e.g., network speeds, coverage or user experience) that can be considered.

- **Greater fixed-mobile convergence** primarily at retail level and greater fixed-mobile substitution. We examine the competitive and consumer impacts of bundling in France, the Netherlands, Portugal and Spain, and also examine higher take-up of mobile than fixed services (fixed-mobile substitution) in Finland.

- **Increasing influence of big tech** in different points across the mobile supply chain. We present a thematic chapter to capture existing activities and developing presence of big tech companies within the mobile supply chain.

1.1 Study approach

The approach to the study is based on a combination of desk research and interviews with industry stakeholders and experts.

The desk research draws on multiple data sources including databases, statistics and research reports from national regulators, industry groups and research institutions, and annual reports from relevant operators.

We have also gathered input from selected regulators and mobile operators in different markets to gain further insights on delivery of high quality networks and/or fixed-mobile convergence and specific regulatory environments in particular markets.

1.2 Report structure

The rest of this report is structured as follows:

- Section 2 highlights the key findings and potential consideration for Ofcom's mobile strategy review based on the high quality network (HQN) case studies. This includes a high-level discussion of the drivers that have delivered high-quality in these markets along with additional considerations for network performance measurement.

- Section 3 sets out the key findings of the fixed-mobile convergence (FMC) market case studies with a discussion on the drivers of FMC and consumer impacts. This includes discussion on potential application to the UK.

- Section 4 focuses on big tech's activity and influence in the mobile supply chain at present and potential developments of big tech's future role, with relevant international examples highlighted throughout.
- Further information is provided in the appendices on UK mobile operators' performance (Appendix A) and Opensignal's scoring criteria for user experience (Appendix B).

2 High quality networks

2.1 What constitutes high quality mobile networks?

Digital technologies are becoming ever more central to our daily lives. As networks, devices and applications continue to improve and evolve, understanding network quality is becoming increasingly important for network operators, consumers and regulators.

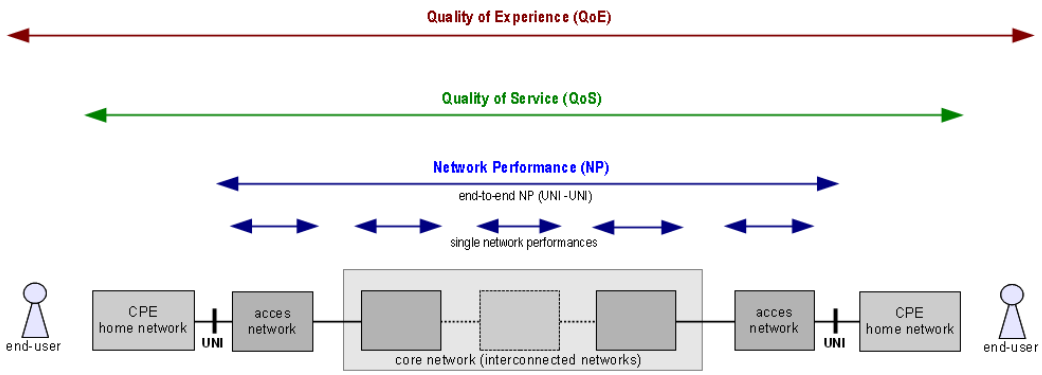
At the fundamental level the quality of mobile networks can be considered from the technical perspective in terms of network performance or from the consumer perspective in terms of user experience. However, the complexity of today's communications networks means there are many factors at the network level and along the value chain, e.g., the device, hardware, infrastructure, service and applications, that can impact on quality.

Network quality is commonly discussed in the following ways:

- Quality of Experience (QoE) – overall performance at the services/application level from a user perspective. QoE focuses on the entire service experience and includes the whole path from user to user including the end-user expectation, perception and context of use.
- Quality of Service (QoS) – network performance at the bit/packet level. QoS typically concerns the network and terminal equipment up to the user interface, though it can also be narrower in scope taking account of just the access and core network excluding terminal performance.

Figure 2.1 illustrates the relationship between these concepts.

Figure 2.1: QoS and QoE concepts



Source: BEREC

The science of measurement of network quality is evolving. There is a gap between parameters used to assess network performance, which has focused heavily on data speeds in recent years, and those that deliver good network quality performance. The typical measures of QoS used by national regulators are shown in Figure 2.2.

Figure 2.2: Most widely used QoS indicators

Category	Indicators
Internet (delivered by fixed and mobile networks)	Data transfer speed (maximum, minimum, typical); web page load time; latency; jitter; packet loss rate
Voice	Call set-up time; unsuccessful call rate; speech transmission quality; response time for calls to the operator; customer service and directory assistance
Mobile	Network availability; probability of successful connection in an area covered by the network; dropped call ratio
Customer service	Time between request for service and start of service; fault frequency; time to troubleshoot and eliminate faults; frequency of complaints about billing
Emergency calls	Total number of 112 calls per year; 112 calls as a percentage of total emergency calls; percentage of false calls; average time to answer; percentage of calls answered within 10 seconds; call abandon rate; average time needed for operator to receive caller's location

Source: Stiftelsen IMIT study for the European Commission.

MNOs are increasingly developing their assessment of Quality of Experience (QoE) and Quality of Service (QoS). Examples of other parameters that could be considered include latency, jitter, packet loss performance, end to end service performance. Cell dimensioning and overhead allowances in traffic planning are also important to ensure that cells can deliver the capacity required for simultaneous traffic demands on a cell.

Coverage is also key to delivery of quality networks, although much has already been done to improve mobile coverage. However, the combination of coverage and capacity at a location is key for assessing the quality of networks. At present, these metrics tend not to be publicly reported by MNOs and regulators.

At a broader level, it is important to understand the relationship between quality and willingness to pay for quality (among consumers and other potential users such as enterprise customers) as these impact MNOs' network planning and investment decisions, as well as regulators' spectrum management approaches.

Example: Quality attenuation approach (ΔQ)

A considerable amount of work has been done on quality of both fixed and mobile networks. An example of this is the Quality Attenuation Approach being developed by the Broadband Forum. This uses a statistical approach and considers application specific demands and needs. The Quality Attenuation Framework is an approach to systems performance analysis that has applicability to broadband networks. It gives far greater insight than simply using speed test results as a proxy for quality of experience.

While this approach was initially developed for fixed broadband networks, its concepts can be applied to any network. Vodafone has been a proponent of this approach.

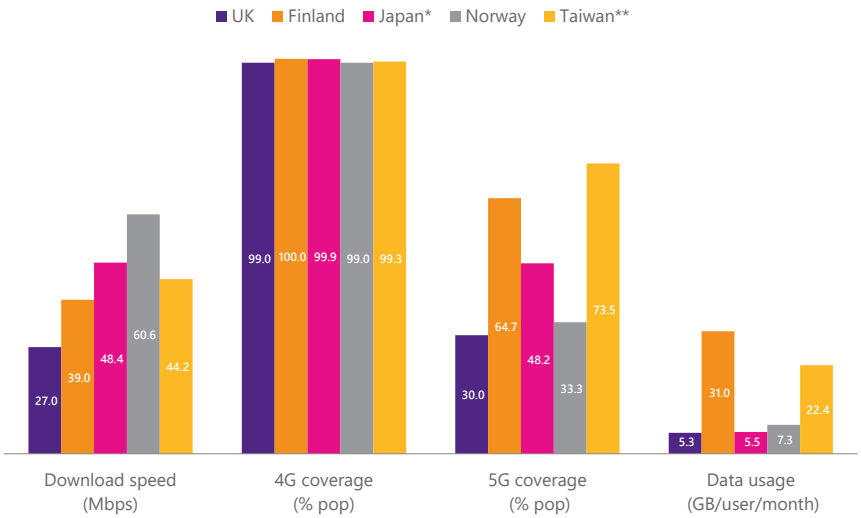
2.2 Quality indicators and UK position

We consider here the common quality indicators that are reported by MNOs, regulators and other industry players, such as network coverage, speeds (download and upload) and network availability. In addition, we also review the supply of spectrum for MNOs and relevant policy and regulatory measures, and market developments, which may explain network quality observed in the selected case study markets.

On the consumer side, we consider more subjective measures relating to user experience with common mobile applications such as video, gaming and voice (VoIP) apps as reported by Opensignal.[12] Demand-side indicators such as mobile data usage trends which could affect network quality are also taken into account.

Four advanced markets – Finland, Japan, Norway and Taiwan – were selected for study with each reflecting a different performance measure such as network speeds, network coverage (including 5G rollout), user network experiences, and data usage. Figure 2.3 shows the performance of the UK and case study markets against several quality metrics. Further information on UK MNOs' performance is provided in Appendix A.

Figure 2.3: Quality and consumption measure comparison



Source: Country-aggregate download speed provided to Plum by Opensignal (2021 Q1), network coverage by GSMA Intelligence (2021 Q2), data usage from OECD (2020). Based on most recent data available.
Notes: * reported by MIC (2020), ** reported by NCC (2020).

UK network quality is marginally lower across these metrics, apart from 4G population coverage. Notably, the selected markets do not necessarily have high performance across all of the metrics. For example, Norway reports the highest average download speeds, yet it has the lowest 5G coverage[13] and lower data usage.

An important consideration in quality of service is data usage. It is important to acknowledge that lower data demand may be reflected in improved network speeds as network capacity constraints are less likely to occur. Higher quality networks can also contribute to increased data consumption by supporting more data-intensive services such as high-definition video streaming and gaming. In other instances, higher quality networks may accelerate the rate of data transfer, providing increased quality of experience for existing services. At the same time, there are a range of market factors that impact on mobile data usage. These are consumer preferences, pricing and availability of alternative connectivity options. Both Finland and Taiwan report high data usage and the performance of their MNOs rank highly in terms of 5G population coverage and network download speeds (relatively lower speeds than other case studies but exceed UK network speeds).

[12] Opensignal, March 2021, Global Mobile Network Experience Awards 2021. Available at: https://www.Opensignal.com/reports/2021/03/global-state-of-the-mobile-network-experience-awards

[13] We consider 5G population coverage in the context of the enhanced mobile broadband use case. When it comes to other 5G uses including massive IoT and ultra-reliable, low latency communications, coverage specified in terms of population is less relevant, and other QoS indicators such as latency and jitter are more important. See Report ITU-R M.2410-0 (November 2017). Minimum requirements related to technical performance for IMT-2020 radio interface(s), and Report ITU-R M.2441-0 (November 2018). Emerging usage of the terrestrial component of International Mobile Telecommunication (IMT).

Figure 2.4 compares the network performance across the five markets in terms of download and upload speed. While the UK's top performer EE is comparable to leading operators in the four markets, the performances of the other three UK MNOs are lagging slightly on this indicator.

Figure 2.4: Network performance comparison – download and upload speeds

Market	Download speeds (Mbps)	Upload speeds (Mbps)	Comments
Finland	34.5 – 40.4	10.8 – 13.4	Download speeds increase relative to market share.
Japan	20.7 – 54.5	8.3 – 11.6	Download speeds for three established operators exceed 40 Mbps. New entrant Rakuten's performance is lower.
Norway	36.0 – 71.6	11.5 – 13.6	Variation in performance similar to UK. Largest player Telenor has highest download speeds; 15 Mbps faster than next best operator Telia.
Taiwan	17.0 – 44.2	4.8 – 11.1	Largest three operators (85% market share) provide download speeds exceeding 30 Mbps. Smaller operators provide lower network quality.
UK	17.1 – 44.0	5.4 – 6.3	EE top performer for network speeds. Substantial difference in user network speeds than other three UK operators who are delivering download speeds below 26 Mbps.

Source: Opensignal (2021, most recent data available)

In the UK, the operators have 99% 4G population coverage apart from Three which has 94% coverage. This is broadly comparable with the HQN comparator markets, where the leading operators have near complete population coverage and smaller operators (for example, Rakuten in Japan and Taiwan Star in Taiwan) have noticeably lower coverage. However, 4G availability[14] is noticeably lower than the HQN markets; only EE users can connect to the 4G network more than 90% of the time. UK operators' 5G population coverage is comparable to Norway, though the operator-specific coverage is noticeably lower than operators in Finland, Japan and Taiwan. These comparisons are highlighted in Figure 2.5.

Figure 2.5: Network performance comparison – network availability and coverage

Market	4G availability	4G population coverage	5G population coverage
Finland	92.8 – 94.7%	99.5 – 100.0%	47.4 – 70.4%
Japan	98.0 – 99.7%	90.0 – 99.9%	8.5 – 48.2%
Norway	97.1 – 97.6%	99.0 – 99.0%	17.2 – 33.0%
Taiwan	92.8 – 96.8%	87.6 – 99.3%	31.2 – 73.5%
UK	81.2 – 93.6%	94.0 – 99.0%	17.8 – 30.0%

Source: Opensignal (2021; most recent reported) and GSMA Intelligence (June 2021)

Figure 2.6 compares the user experience for video, gaming, and voice app on mobile networks for the UK and HQN markets as reported by Opensignal. The results for UK operators indicate that user experience is lower across all metrics. In particular, the UK's highest scoring network in terms of voice app and gaming experience performs below the lowest performing operators from the HQN markets.

[14] Opensignal's 4G availability network reflects the percentage of time that users can connect to a 4G network. This data is collected from Opensignal users, and the value is not adjusted to account for user location or population density in urban or rural areas etc.

Figure 2.6: User experience comparison, score out of 100 (2021)

Market	Video experience	Gaming experience	Voice app experience
Finland	76.3 – 77.7 [Excellent]	74.2 – 75.8 [Fair – Good]	81.6 – 82.1 [Good]
Japan	68.7 – 80.0 [Very Good – Excellent]	77.8 – 82.7 [Good]	81.7 – 83.1 [Good]
Norway	77.3 – 80.1 [Excellent]	74.4 – 78.0 [Fair – Good]	82.3 – 83.4 [Good]
Taiwan	71.0 – 77.3 [Very Good – Excellent]	68.0 – 77.5 [Fair – Good]	79.0 – 81.5 [Acceptable – Good]
UK	66.1 – 72.0 [Very Good]	55.5 – 65.7 [Poor – Fair]	76.7 – 78.4 [Acceptable]

Source: Opensignal (2021; most recent reported)

2.2.1 Service pricing

Retail prices and tariff features for mobile services vary significantly across the HQN markets and the UK. In most cases, mobile tariffs reflect data allowances rather than connection (or network) speeds. In the markets where connection speeds are specified as part of the mobile tariff (Finland, Norway and Taiwan depending on package type), operators differentiate prices and compete on, a secondary base, on quality of service.

It is difficult to assess the impact of high quality provision on current or future pricing without access to historical data on trends. International price comparisons have primarily compared basket prices for tariffs with similar voice and data allowances and do not consider network quality.[15] These comparisons tend to reflect the lowest price offers that meet the basket threshold allowance, meaning that this may not reflect higher quality tariffs, such as subscriptions with higher connection speeds or a 5G service instead of 4G.

Figure 2.7 compares mobile prices for packages of different quality in the UK and HQN markets. The pricing data, excluding Taiwan, comes from a 2020 study published by the European Commission[16] and is based on the lowest price retail offer. Prices for Taiwan are based on the leading carrier's offers at the time of writing[17] which means these may not be directly comparable to the rest of the pricing data.

Figure 2.7: Comparison of HQN mobile services (EUR PPP)

Market	Mobile basket 1 (0.5 GB data, 30 calls)	Mobile basket 2 (2 GB data, 100 calls)	Mobile basket 3 (20 GB data, 100 calls)
Finland	7.86	15.20	15.20
Japan	21.05	31.98	63.30
Norway	11.93	17.57	37.33
Taiwan*	9.18	14.73	49.23

[15] For example, the price comparison methodologies used by both the OECD/Teligen and the ITU do not account or control for difference in average network speeds or mobile pricing that may be tiered by connection speed.
[16] Empirica and TÜV Rheinland for European Commission, 2020, Mobile and Fixed Broadband Prices in Europe 2019. Available at https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=72471
[17] Prices are for Chunghwa Telecom as of October 2021. Available at https://www.cht.com.tw/en/home/cht/about-cht/products-and-services/mobile/post-paid-services

Market	Mobile basket 1 (0.5 GB data, 30 calls)	Mobile basket 2 (2 GB data, 100 calls)	Mobile basket 3 (20 GB data, 100 calls)
UK	9.08	10.09	17.66
EU27	10.38	15.87	31.51
US	36.50	46.50	67.79

Notes: Based on least expensive offers in each market, except for Taiwan. * Prices from Chunghwa Telecom.
Source: European Commission, CHT (Taiwan).

There is a significant variation in pricing with UK sitting in the lower to middle range of mobile pricing. Overall prices in Finland and Taiwan tend to be in a similar range to the UK, with the lower basket 1 (0.5 GB, 30 calls) costing less. In contrast, prices in Japan are significantly higher than the UK and other HQN markets.

In general higher prices are observed for larger allowance packages (and diminishing price per GB) for all markets although the price gradient differs across baskets. In Finland baskets 2 and 3 are similar in price, in contrast to the other markets where basket 3 is typically priced at a premium with substantial variations in the price for 2 GB and 20 GB of data. The price differential between baskets 1 and 2 in the UK is the smallest among the HQN markets surveyed.

There is no clear evidence that higher quality network provision is associated with higher mobile prices. However, it is interesting to consider how operators in HQN markets differentiate their prices and packages.

2.2.2 Consumer choice over QoS

In the UK, prices for mobile services tend to depend on allowances for mobile data, voice and international roaming. Connection speeds tend not to be a feature of mobile tariffs, with connection speeds for premium 5G connections generally offered as "fastest available" speeds.[18] This is similar to Japan, where network speeds are not advertised as part of retail offerings.

In contrast to the UK and Japan, connection speed is a key feature of mobile pricing in Finland. Unlimited data plans have become the norm, with the prices of 4G and 5G packages being differentiated by features of maximum download speeds and EU roaming allowance. For example, Telia allows consumers to select the maximum internet speed when choosing their mobile broadband package with varying price adjustments whereas DNA specifies the speeds as part of the tariff. Higher speed packages are reflected through higher prices, though the diminishing cost applies.

Mobile offers in Norway tend to vary by data allowance, though operators report connection speeds. Telenor, the largest and highest-pricing carrier, is the only operator that allows subscribers to select connection speed for unlimited data packages. Maximum connection speeds are advertised by Telia and for Telenor's other packages. ICE, the smallest and lowest-pricing carrier, only specifies network speeds in regards bandwidth throttling once the data allowance has been consumed.

In Taiwan, network speeds are commonly advertised as part of mobile tariffs, though these are predominantly a capped data allowance offering a lower network speed or an unlimited data allowance with faster speeds.[19] Faster network speeds are advertised as part of larger data allowances and higher quality packages (e.g., sharing of data allowances, no speed throttling). Data speed throttling is a common feature of 4G mobile packages once consumers have exceeded their data allowance, and the limitations on speeds are included as part of the tariff information advertised. For 4G, this practice works more for quality and network management purposes,

[18] Based on Plum survey of MNO retail offerings in UK. Vodafone, for example, specify speeds as "fastest available" for its range of unlimited 5G-ready tariffs but do not advertise or specify speeds for other mobile packages.
[19] Based on Plum survey of MNO retail offerings.

particularly given the majority of mobile users in Taiwan are on 4G with unlimited data plans. For 5G, MNOs appear to be using this as a pricing strategy at present with different 5G price tiers offering a differentiated speed reduction once the data allowance has been reached.

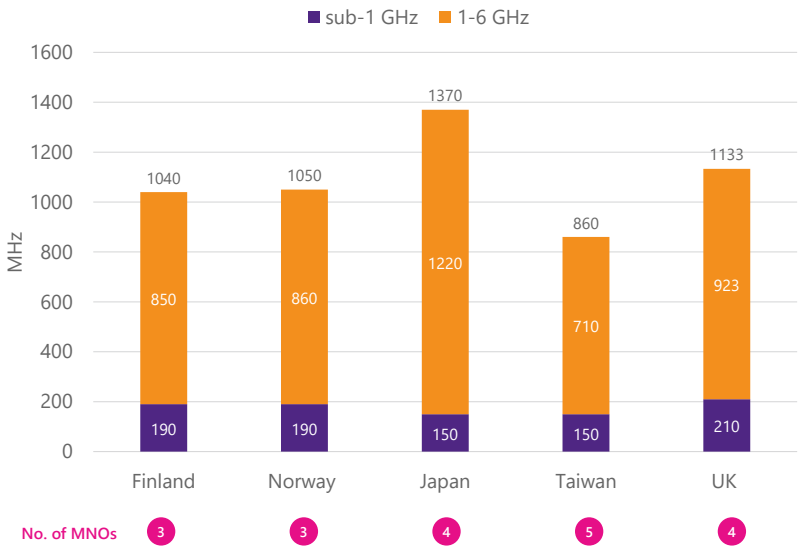
Based on current offers in HQN markets and the shift towards large or unlimited data allowances for 4G and 5G services, connection speeds may become an advertised feature of UK operators' retail offerings in the future. Whether mobile plans will also offer consumer choice over connection speeds, such as in Finland or Norway, remains uncertain given that this is not so far widely observed in the other HQN markets.

2.2.3 Spectrum aspects

Radio spectrum is an essential input for the provision of mobile services. The last ten years has been characterised by rapid growth in mobile data traffic and this trend is likely to continue with the evolution of mobile networks from 4G to 5G and beyond. As the adoption of 5G increases in the coming years, there will be the need to expand network capacity to support demand driven by enhanced mobile broadband (eMBB) services, and also to cater to private 5G network solutions to meet the requirements of enterprise verticals and IoT users. At the same time, it is important that MNOs continue to improve coverage and service quality in rural areas to enable citizens to benefit from 5G and address the connectivity gaps and the digital divide.

MNOs need access to a combination of low, mid and high frequency bands[20] to fully serve 5G use cases. The ample supply of spectrum is thus a key component for high quality networks. Figure 2.8 compares the spectrum assigned to MNOs in the low- and mid-band frequency ranges.[21] Japan is a leader in this regard, having released a significant amount of mid-band spectrum in 2019. As of October 2021, the UK is in a similar position to Finland and Norway though there are differences in the timing of spectrum release as further discussed in the individual case studies below. In Taiwan there is less spectrum assigned for MNOs in the mid-band range due to incumbent services in the 3.5 GHz range.

Figure 2.8: Spectrum assigned to MNOs in selected HQN markets (October 2021)



Source: Plum analysis based on data from ECO, APT and national regulators

[20] Low bands are those below 1 GHz, mid-bands are typically between 1 to 6 GHz and high-bands refer to mm-wave frequencies above 24 GHz.
[21] These frequencies tend to be in high demand compared to high-band or mm-wave spectrum for which 5G use cases and business models are still emerging.

Aside from spectrum availability, there are also a number of other factors and considerations that can influence network quality and user experience, including:

- **Market structure**. In general a higher number of MNOs reduces the amount of spectrum available for each MNO, which could lead to sub-optimal outcomes for consumers in terms of higher network costs or lower service quality. However, this needs to be balanced against the benefits of market competition which could have the impact of lowering prices and promoting innovation. Most advanced mobile markets, including those examined in this study, tend to feature three or four MNOs. In Taiwan where there are five MNOs and a highly competitive market environment, the comparatively smaller spectrum holdings per MNO (around 170 MHz compared to 350 MHz for Norway and Finland) and high mobile data usage have led to MNOs taking steps[22] to increase capacity and to maintain or improve quality of service.

- **Geography and network deployment**. Network deployment and costs are heavily influenced by the specific geographical characteristics of each market. In highly populated urban environments, dense high-capacity networks including small cells will be necessary to meet traffic demand. The provision of mobile coverage in sparsely populated rural regions presents different challenges in terms of network planning and the investment case. While commercial arrangements among operators can help overcome some of these challenges (such as rural sharing arrangements in Finland and the UK), in most markets there tend to be some form of policy or regulatory intervention aimed at ensuring adequate network coverage and level of service quality.

- **Technology aspects**. Spectrum is a finite and scarce resource, particularly in the low and mid bands. Thus, improving spectral efficiency (in terms of data rate that can be transmitted over a given bandwidth) is key to delivering high quality networks. For mobile networks, spectral efficiency depends on technology deployed (2G, 3G, 4G or 5G), the associated equipment specifications and network configuration. Each generation delivers significant efficiency improvements over its predecessor.[23] Hence, the phasing out of legacy 2G and 3G networks and spectrum refarming to support the most advanced technologies is an important strategy for MNOs to meet the demands of growing mobile data consumption. Other technical options, such as spectrum sharing and network segmentation through slicing, can boost spectrum utilisation and improve efficiency and network quality.

2.3 Summary of HQN drivers and impacts

This section provides an overview of the drivers and impacts of high quality network provision in the selected leading markets – Finland, Japan, Taiwan, and Norway. Figure 2.9 highlights the key drivers for provision of high quality networks and the role of consumer awareness.

[22] Such as network densification and the phasing out 2G and 3G services to refarm spectrum for 4G. The number of cell sites per unit area is notably higher than the other HQN markets.

[23] For example, 5G is around three times more spectrally efficient than 4G although there is considerable variation depending on environment and deployment scenarios. Source: 5G Americas, September 2019, LTE to 5G: Cellular and Broadband Innovation. Available at: https://www.5gamericas.org/wp-content/uploads/2019/09/Global-5G_Implications-of-a-Transformational-Technology_Reference-Presentation.pdf

Figure 2.9: Key findings from HQN case studies

Market	Mobile connectivity and use of mobile services	Drivers of HQN?	Consumer awareness and choice over QoS
UK	• 5G launched in 2019, population coverage at 30% (Q2 2021). • Mid-low mobile data usage, 5.3 GB/user/month.	• **Coverage obligations:** Proposed obligations for 5G 700 MHz and 3.5 GHz auction removed due to Shared Rural Network. Geographic and population coverage obligations attached to previous 800 MHz/2100 MHz and 900/1800 MHz assignments. • **Network sharing:** Shared Rural Network initiative between UK Gov and four MNOs to extend 4G coverage nationwide. • **Spectrum sharing & local licensing:** Arrangements for 5G verticals and private networks. • **NGA support:** UK Gov funding for NGA rollout focused on fixed connectivity rather than MBB. • **Switch-off:** No 2G/3G switch off – press reports indicate mid-late 2020s.	• **Speeds in tariff offer?** Network speeds are not a common feature of tariffs. Where advertised, offer best connection available or 5G superfast speeds for premium services. • **Public QoS reporting**: Ofcom report on MNOs coverage (indoor/outdoor, 4G/no 4G) across UK postcodes via its Broadband and Mobile Checker tool.
Finland	• 5G launched in 2019, population coverage at 65% (Q2 2021). • Very high data usage 30.99 GB/user/month. • Large proportion MBB-only home subscribers driven by unlimited data packages and lower FBB penetration.	• **Speed as a competitive dimension:** advertised in tariffs. • **Timely spectrum:** Early access to key spectrum bands. • **Network sharing:** Between Telia and DNA to support rural mobile and 5G coverage. • **Coverage obligations:** Sub-1 GHz spectrum licence includes obligation to provide indoor coverage. • **Local licensing:** Broader support for local 4G/5G networks through light licensing. No licence needed for construction of 5G base stations. • **Reduced regulatory barriers**: No licence needed for construction of 5G base stations.	• **Speeds in tariff offer?** Network speeds are a common feature of tariffs with consumers able to select connection speed. • **Public QoS reporting**: Traficom plans to introduce independent speed/QoS monitoring and comparison site. Each MNO currently hosts coverage maps for own network on their websites.

Market	Mobile connectivity and use of mobile services	Drivers of HQN?	Consumer awareness and choice over QoS
Japan	• 5G launched in 2020, population coverage at 48% (Q2 2021). • Mid-low mobile data usage, 5.05 GB/user/month.	• **Government intervention and regulator policy:** Managed approach to HQN technology and spectrum usage. • **NRA QoS monitoring:** MIC monitors spectrum usage and efficiency, including MNO rollout and deployment of advanced technology protocols. • **Timely spectrum:** Early access to key spectrum bands, though not always harmonised globally. • **Financial incentives:** Tax incentives introduced to support 5G investments. • **NGA support:** Extensive fibre connectivity, for backhaul and subscribers Wi-Fi offloading. • **Switch-off:** 2G switched off since 2012.	• **Speeds in tariff offer?** Network speeds not reported as part of MNO tariff offers. • **Public QoS reporting**: QoS is monitored, and network performance metrics published as part of MIC's statistical publications. However, there does not appear to be a consumer tool to compare MNO networks. • All 4 MNOs amongst top international HQN performers (Opensignal).
Norway	• 5G launched in 2020, population coverage at 33% (Q2 2021). • Average data usage 7.3 GB/user/month.	• **Government and regulatory interventions** to facilitate a third MNO and promote effective competition to two main MNOs (including SMP and merger remedies). • **NRA QoS monitoring:** Operator obligations related to measuring and notifying Nkom of network quality. • **Coverage obligations & financial incentives:** Auction process includes financial incentives and spectrum fee discounts for taking on obligations to improve quality of rural broadband in recent 2021 5G award (2.6 GHz and 3.5 GHz) and coverage of transport routes in the 2019 award (700 MHz and 2100 MHz). • **Switch-off:** 3G switch-off planned (2021).	• **Speeds in tariff offer?** Networks speeds advertised as part of packages, though only Telenor offer their unlimited data subscribers' choice of connection speed. • **Public QoS reporting**: MNOs subject to QoS reporting obligation and monitoring by Nkom, though detailed figures are not publicly available. Nkom publishes annual broadband coverage map showing speed and technology type (mobile, FWA, etc). • Similar coverage though differential in download speed.

Market	Mobile connectivity and use of mobile services	Drivers of HQN?	Consumer awareness and choice over QoS
Taiwan	• 5G launched in 2020, population coverage at 74% (Q2 2021). • Very high data usage 22.4 GB/user/month. • Majority of users are on unlimited data plans.	• **Quality driven by competition:** High level of market competition with 5 MNOs. • **Network and spectrum sharing:** Updated regulations to facilitate 5G network and spectrum sharing. • **Financial incentives:** Government financial support, including 4G demand-side initiatives and 5G rollout subsidies for operators. • **Switch-off:** Spectrum constraints has led to re-farming of 2G and 3G spectrum. 2G switched off (2017), 3G only for CSFB (2018).	• **Speeds in tariff offer?** Network speeds advertised though connection speeds are most commonly stated with regards to throttled speed once initial data allowance exceeded. • **Public QoS reporting**: MNOs required to publish information on signal coverage and reception quality, and Wi-Fi hotspots. Research on network performance is published annually.

To understand the drivers and impacts of the provision of high quality networks, we have considered selected advanced markets, namely Finland, Japan, Norway, and Taiwan. These examples also reflect different market and regulatory environments which have influenced service quality. A summary of the main findings are as follows.

- There are several different measures that can be applied to assess network quality. Each HQN market is a high performer with regard to a different metric. For example, Japan's MNOs rank as leading operators in terms of user experience whereas Norway has the highest average download speed.

- In terms of mobile connectivity, the UK performs lower on average than the selected HQN markets. In particular, the UK lags behind on network speeds and 5G coverage. The UK data usage ranks within the mid-low range of OECD countries and is significantly lower than Finland and Taiwan where popularity of unlimited data plans, consumer habits and fixed-mobile substitution has resulted in very high mobile data consumption.

- High quality of service has been primarily driven by a combination of market factors and regulatory policy. In the HQN markets, the operators tend to have established market shares and primarily compete on price and nature of the data packages. Network speeds and coverage tend to be secondary aspects of competition. The experiences vary significantly across the HQN markets.

  - In Finland a stable market structure with timely release of ample spectrum and extensive network and spectrum sharing across rural areas are important factors. The requirements on MNOs to provide indoor coverage as part of spectrum licensing is also another factor.

  - In Japan, the highly planned, supply-focused approach to spectrum management involves tight regulatory oversight of technologies deployed and network performance. This has ensured early deployment of advanced network protocols and availability of high quality networks.

  - In Norway, regulatory interventions such as Significant Market Power (SMP) obligations and merger remedies have been important in facilitating the growth of a credible third MNO to ensure an adequate level of competition at the retail level.

  - In Taiwan, intense competition has led to low prices and high usage, but MNOs have managed to sustain high quality with denser networks and by refarming spectrum following the phase out of 2G and 3G services. Recent changes to introduce more flexibility for network and spectrum sharing by

MNOs aim to address concerns over 5G deployment costs and to safeguard consumers by maintaining a competitive 5G environment.

  - Financial incentives to support deployment of high quality mobile networks, targeting rapid 5G rollout or rural broadband provision, are common.

- In terms of consumer preferences and choice, there is limited information regarding consumers' ability to identify and choose between different quality of service. Each regulator monitors network quality though the number of quality measures (primarily coverage and user support) vary as does the approach. For example, the Finnish regulator is developing an independent crowdsourcing tool accessible to consumers, and in Taiwan network coverage and quality information is published by the regulator and by MNOs. MNOs in Norway are required to submit performance information to the regulator, though this is not publicly reported. In our review, however, we have found no evidence to suggest whether consumers access this information and, if so, how this informs their choice.

- Similarly, there is little evidence as to how provision of high quality connectivity and associated investment costs impact retail prices. In the case of Taiwan and Japan, price competition (or lack thereof) has been a driving factor in observed price levels. Network quality (in terms of speeds) are not commonly factored into price level. In Norway and Finland, some of the mobile operators allow mobile subscribers to select network speeds as part of mobile plans with unlimited data allowance.

2.4 Finland

Motivation for selection: High mobile data consumption with high network coverage and speed

Key market & supply chain features	
Mobile network operators (subscriber share)	Elisa (35-40%), Telia (30-35%), DNA (25-30%) (2021 Q2)
Mobile virtual network operators	6 MVNOs: Moi, Aiva Mobile (MTT), Ainacom, Globetel, Satera, Tismu
Other notable players in broadband supply chain	Elisa, Telia and DNA all operate as fixed ISPs, in addition there is the Finnet Association (central organisation and co-operative forum of local ICT companies; <10% share of fixed connections) and other small regional players such as Cinia (purchased regional Oulu-based ISP and wholesaler Netplaza in 2018).
LTE coverage (% population)	100% (2021 Q2)
5G coverage (% population)	64.7% (2021 Q2)
Data speeds (average download & upload) – LTE	39.0 Mbps download, 12.4 Mbps upload (2021 Q2)
Network availability – LTE	92.8% to 94.7% - varies by operator (2021 Q2)
Sub-6 GHz assigned for MNOs	1040 MHz
Sub-1 GHz assigned for MNOs	190 MHz
Total cells, excluding 5G (thousands)	253.9
Total cells / 000' pop	45.9
Total cells / sq.km	0.83
Population (million)	5.53 (2020)
Rural population (%)	14.5% (2020)
Land Area (sq.km)	303,920 (2020)
GDP per capita (US$, current)	US$ 49,041 (2020)
Mobile broadband penetration (%)	155.8% (2020)
Mobile data usage (GB/month/sub)	30.99 GB (2020)

Source: Plum, GSMA Intelligence (2021 Q2), analysis by Opensignal (2021 Q1 values), World Bank (2020 values), OECD (2020 values), OpenCellid (October 2021).

2.4.1 Market overview and key players

There are three established MNOs in Finland – DNA, Elisa and Telia. In August 2019, Norway-based telco Telenor Group acquired a majority stake in DNA. In addition to the three MNOs, GSMA Intelligence reports six live MVNOs currently active in Finland, four of which are hosted on DNA's network. Figure 2.10 shows the change in market share by subscriptions over the last six years.

Figure 2.10: Market shares by subscribers (2015 vs 2021)

Operator	Market share in Q2 2015	Market share in Q2 2021
Elisa	40 – 45%	35 – 40%

Operator	Market share in Q2 2015	Market share in Q2 2021
Telia	30 – 35%	30 – 35%
DNA	23 – 27%	25 – 30%
Other	<1%	>1%

Source: GSMA Intelligence

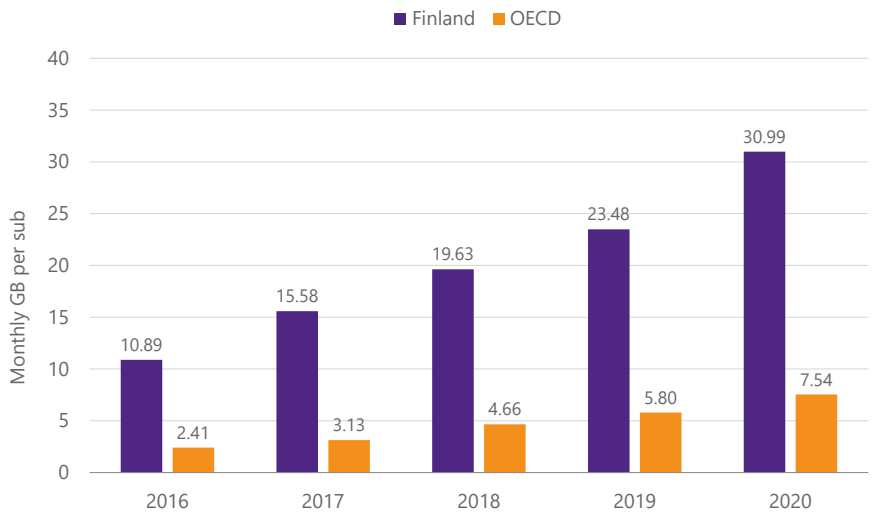
In Northern and Eastern Finland, Telia and DNA jointly operate the Finnish Shared Network Ltd (SYV). SYV does not offer services directly to subscribers or wholesale service to other MNOs.

The three MNOs each have their own fixed networks, providing wholesale access and retail ISP services. There are also a small number of regional players and cooperatives that operate as fixed wholesalers and ISPs. The majority of these are a part of the Finnet Association. These collectively represent less than 10% share of Finland's telecommunications revenues.

2.4.2 Network performance and usage

Finland has the highest mobile data consumption per subscription amongst the OECD countries with a monthly average per subscription of 30.99 GB in 2020. This represents more than four times the OECD average of 7.54 GB, as shown in Figure 2.11. Finland's monthly data consumption has risen almost three-fold from 10.89 GB per user in 2016.[24] As of Q2 2021 the majority of mobile connections are 4G (80% of total connections), though 2G and 3G retain significant shares (4% and 11% respectively) while 5G connections make up 5%.[25]

Figure 2.11: Mobile data usage trends – Finland vs OECD



Source: OECD

Finland was among the earliest markets to deploy 4G in 2010 and 4G coverage had reached 99% of population by 2014.[26] The current level of 4G coverage is 100%. The early investment in 4G has been accompanied by data-

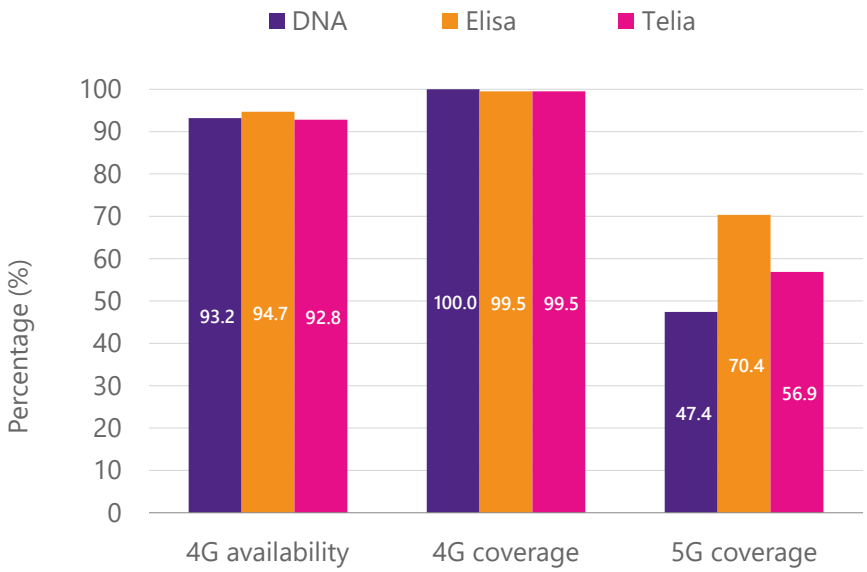
[24] OECD, 2021, Broadband Portal – Penetration and data usage. Available at: https://www.oecd.org/digital/broadband/broadband-statistics/ Statistics: Mobile data usage per mobile broadband subscription.
[25] Source: GSMA Intelligence, 2021.
[26] Source: GSMA Intelligence, 2021.

rate pricing, as opposed to packages with strict data caps which are common in many markets. This has meant that mobile broadband usage became the norm at an earlier stage than in other markets, including the UK.

The rising mobile data usage is also reflected in the increasing proportion of households using only mobile broadband at home, which at 36% as of 2019, is the highest across the whole of the EU (the EU average is 11%).[27] This suggests a degree of fixed-mobile substitution in Finland – overall fixed broadband household take-up (57% as of 2019) in Finland lags behind the EU average of 78%.[28]

Figure 2.12 reports 4G and 5G network coverage by population and 4G availability metric (percentage of time users can connect to the 4G network). The three MNOs introduced 4G between November 2010 and December 2011, and 5G services between July 2019 and January 2020. All three MNOs score very highly for both 4G availability and coverage with high levels of 5G coverage reported in comparison to international benchmarks. As of June 2021, Elisa has the highest 5G coverage of the three MNOs.

Figure 2.12: Network performance – 4G availability (% time accessible) and 4G/5G coverage (% population)



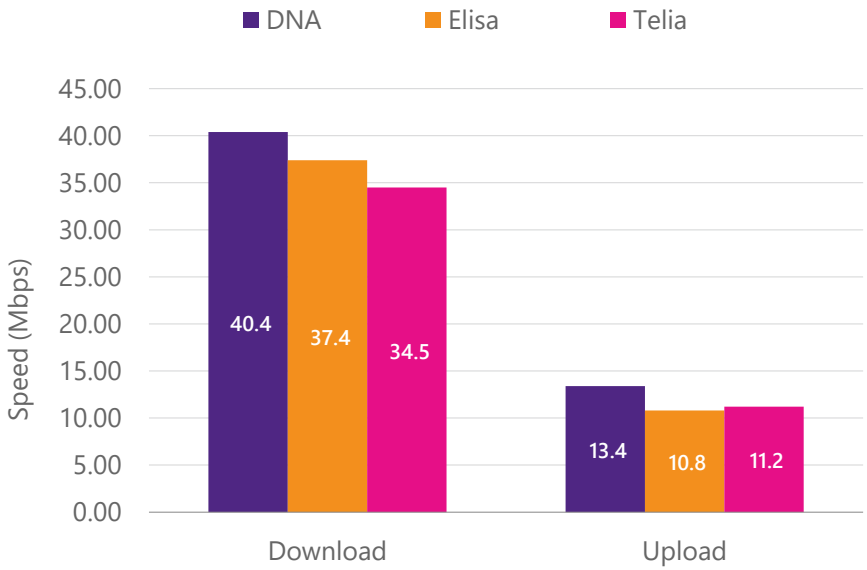
Source: Opensignal (June 2021; 4G availability), GSMA Intelligence (June 2021; 4G population coverage, 5G population coverage)

Figure 2.13 shows average download and upload speeds for the three MNOs as reported by Opensignal in Q2 2021.[29] On average, mobile users in Finland have access to download speeds of 35 Mbps or higher and upload speeds of 11 Mbps or higher. These are significantly above the 2020 global average of 23.6 Mbps (download) and 7.5 Mbps (upload).[30] DNA users experienced the highest download speeds and highest upload speeds; the lowest download speed is experienced by Telia's users.

[27] European Commission, June 2020, Digital Economy and Society Index (DESI) 2020 – Thematic chapters. Figure 32, p.34. Available at https://digital-strategy.ec.europa.eu/en/library/digital-economy-and-society-index-desi-2020
[28] European Commission, June 2020, Digital Economy and Society Index (DESI) 2020 – Thematic chapters.
[29] Opensignal, June 2021, Finland Mobile Network Experience Report. Available at https://www.Opensignal.com/reports/2021/06/finland/mobile-network-experience
[30] Opensignal, March 2021, Global Mobile Network Experience Awards 2021. Available at https://www.Opensignal.com/reports/2021/03/global-state-of-the-mobile-network-experience-awards

In terms of 5G, Finland is among the top 10 performing markets globally as of March 2021 for download and upload speeds.[31] It should be noted that as 5G is still relatively nascent, consumer experience of network performance is only representative of a small subset of 5G-enabled users.

Figure 2.13: Network performance – overall download and upload speed (2021)



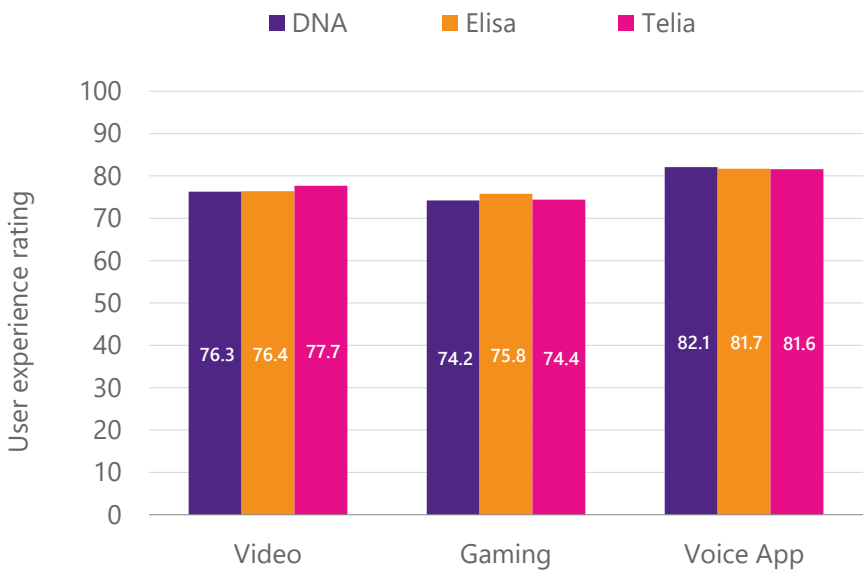
Source: Opensignal (June 2021)

Opensignal's user experience metrics for video experience, gaming experience, and voice app experience are reported in Figure 2.14.[32] The three MNOs score highly across the three categories with statistically tied scores. All three are rated excellent in video experience. Regarding best voice app experience, all three are placed in the good category (score of 80-87). See Appendix B for more details on the scoring criteria.

[31] Opensignal, 15 April 2021, Benchmarking the Global 5G Experience – April 2021. Available at https://www.Opensignal.com/2021/04/15/benchmarking-the-global-5g-experience-april-2021

[32] Further details on Opensignal's methodology for each user experience score is available on their website: https://www.Opensignal.com/methodology-overview

Figure 2.14: User experience score, of 100 (2021)



Source: Opensignal (June 2021)

2.4.3 Policy and regulatory environment

In Finland, the Ministry of Transport and Communications (MoTC) is responsible for overseeing the telecommunications sector in accordance with the *Electronic Communications Services Act*. The objectives of this Act are as follows.

- To foster the supply and use of electronic communications services;
- To secure the efficient and interference-free use of radio frequencies;
- To foster competition;
- To ensure that communications networks and services are technologically advanced, of high quality, reliable, safe, inexpensive; and
- To ensure the confidentiality of electronic communication and the protection of privacy.

In June 2020, the Finnish government proposed a reform of the *Electronic Communications Act* with the objective to include provisions regarding the improvement of the consumers' position, the promotion of both investments into communications networks and the availability of communications services, as well as improving security of communication networks. The new *Telecoms Act* entered force in January 2021, implementing the requirements of the European Electronic Communications Code.[33] It has also put into place measures included in the common toolbox, to secure the EU's 5G networks to protect critical parts of the communications network.

[33] Telecompaper, 8 January 2021, Finland's new telecoms act enters force to facilitate 5G base station set-up, raise minimum broadband speed. Available at: https://www.telecompaper.com/news/finlands-new-telecoms-act-enters-force-to-facilitate-5g-base-station-set-up-raise-minimum-broadband-speed--1367938#:~:text=The%20Finnish%20Ministry%20of%20Transport,network%20security%2C%20among%20other%20things.

The *Radio Frequency Regulation*[34] governs the use of spectrum in Finland. Its objective is to guarantee a fair availability of radio frequencies and efficient, appropriate and sufficiently interference-free use of frequencies.

The Finnish Transport and Communications Agency (Traficom) oversees regulation of the electronic communications sectors, including assignment of radio frequencies and information security. Traficom's actions to promote competition in the mobile market are discussed below.

2.4.3.1 Measures to promote competition

As part of its mandate to promote competition, Traficom conducts regular market reviews to detect the existence of significant market power. Information is collected on prices of regulated products charged by companies and price comparisons are published by the regulator. Regulating such power, enables the regulator to promote competition in communications markets and reduce entry barriers. If a company is found to be operating with significant market power, obligations on such companies may be imposed regarding the following:

- transfer of the right to use a regulated product or service;
- transparency and non-discrimination in service prices and delivery terms; and
- pricing of products or services.

The fulfilment of the imposed obligations is carefully monitored by Traficom. The regulator has also prepared a public roadmap of the regulatory priorities.[35]

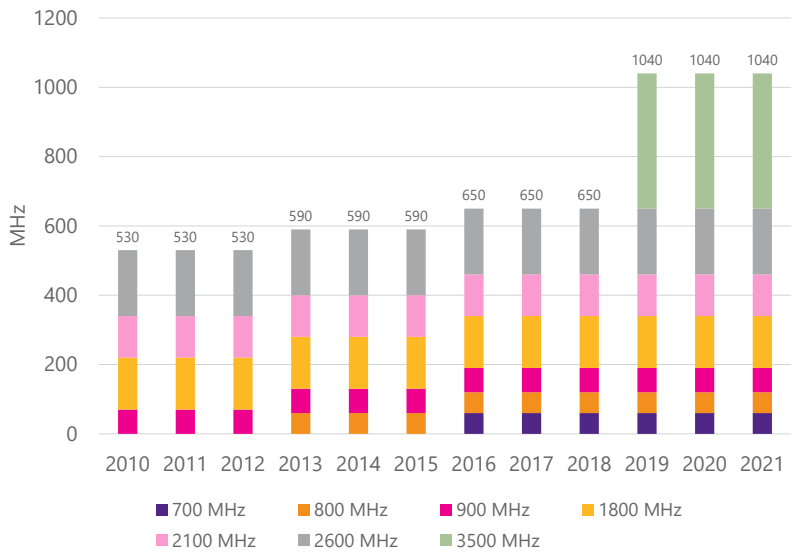
Other measures introduced by Traficom, including monitoring of network speeds and quality, and conditions associated with network licences, are discussed in Section 2.4.3.4.

2.4.3.2 Spectrum policy and management

There is currently more than 1000 MHz of spectrum assigned to the three MNOs in the frequencies below 6 GHz as shown in Figure 2.15. Another 2400 MHz of mm-wave spectrum in the 26 GHz band has also been assigned for IMT use.

[34] Traficom, 20 April 2021, Radio frequency regulation 4 AB/2021M. Available at: https://www.traficom.fi/sites/default/files/media/regulation/Radio%20frequency%20regulation%204AB2021M.pdf
[35] Traficom, 26 March 2018, HMV-sääntöhttps://www.traficom.fi/sites/default/files/media/regulation/HMV-saantelyn_tiekartta.pdf

Figure 2.15: Sub-6 GHz spectrum assigned for mobile services in Finland



Source: ECO, national regulator, Plum analysis

The early availability of spectrum is a key driver for the rollout of LTE in Finland. The Finnish regulator had awarded additional 1800 MHz spectrum to the three MNOs in 2009[36] and they were among the first in the world to deploy LTE using this band. The 1800 MHz band became a mainstream LTE band in the early 2010s due to delays in the release of the 800 MHz digital dividend spectrum. Also, the wider bandwidths available made it possible for high speed mobile broadband to be widely available across the country. By the end of 2015, LTE coverage in Finland had reached 99.9% of population.[37]

Finland was also one of the first markets to assign the full 3.5 GHz band for 5G in October 2018. Each of the three MNOs obtained 130 MHz of contiguous spectrum which enables them to deploy the full 100 MHz carrier to support 5G enhanced mobile broadband. No coverage obligations apply to 3.5 GHz spectrum though previous awards of sub-1 GHz bands (700 MHz in 2016 and 800 MHz in 2013) had included obligations on 4G population coverage, including obligations for providing 'reasonable indoor coverage'.[38]

2.4.3.3 Network and spectrum sharing

The provision for network sharing in Finland is relatively permissive. There are no limits on joint network usage on the condition that an MNO achieves a minimum level of 35% population coverage with its own network.

In Northern and Eastern Finland, Telia and DNA jointly operate the Finnish Shared Network Ltd (SYV), built in cooperation with Nokia.[39] The joint venture (JV) arrangement, in place since 2014, involves RAN and spectrum sharing for 2G, 3G and 4G in the JV´s operating area which covers approximately 50% of Finland's territory and around 15% of the population. The JV arrangement was subject to an investigation by the Finnish Competition and Consumer Authority (FCCA) following a compliant by Elisa, but was approved following a series of

[36] Reuters, 24 April 2009, TeliaSonera Elisa DNA get Finland 4G frequencies. https://www.reuters.com/article/finland-4g-idUSLO30505520090424
[37] Source: ITU WTID, 2021.
[38] 'Reasonable indoor coverage' means that the telecom operator's services must be available without additional cost to users in normal circumstances of use in users' permanent residences or enterprises' places of business. The licence holder is obliged to demonstrate the available of service if required.
[39] Yhteisverkko, 2021, The Shared Network offers speed, better reception and services. Available at: https://yhteisverkko.fi/en/improved-speeds-reception-service-new-shared-network/

commitments by Telia and DNA, including the provision of wholesale access, and renting of mast and equipment location sites to the competitors.[40]

In early 2021, it was announced that SYV would include 5G with the shared network to be expanded geographically to cover 62.5% of the area and 28.5% of the population.[41] The plan for 2021-2023 is to build an extensive 5G network across the Northern and Eastern regions, to offer Telia and DNA customers improved mobile broadband service in terms of coverage, speeds and network performance.[42]

2.4.3.4 Speed and quality monitoring

Finnish consumers do not currently have access to a widely available, non-commercial internet speed measurement tool that produces reliable and objective data on the quality of their internet connections. It should be noted, however, that each of the three MNOs provide their own speed test to allow their subscribers to test their speeds.[43]

To fill this gap, in 2019, the Finnish regulator launched the Bittimittari project[44] with an aim of developing a user-friendly and reliable tool for consumers to test the quality of their internet connections. With the help of Bittimittari, consumers will be able to monitor the speed and quality of fixed and mobile internet connections on their mobile devices and computers. The tool is planned for release to the public in December 2021 and the mobile testing applications will be available on Apple's App Store and Google Play (iOS and Android).

Once available, Bittimittari will use crowdsource data to produce measurement data on the functioning and quality of mobile and fixed networks, enabling public authorities, consumers and businesses to utilise the data in a range of situations, including when assessing the performance of networks or comparing internet subscriptions. The intention is for the data to be published in Traficom's MONITORi service.[45] The exact quality metrics are yet to be defined.

Throughout the Bittimittari project, Traficom has placed particular emphasis on the importance of listening to stakeholders' views and incorporating them in the development process. Workshops are planned to facilitate stakeholder cooperation as the project progresses.

2.4.3.5 Network licences and construction of base stations

The new Finnish *Telecoms Act* provides for new network licensing procedures that are applicable to certain frequencies. This includes the possibility to extend the validity of the network licences granted and the possibility to renew an expiring network licence without an open application procedure.

The Act also includes provisions for facilitating construction of 5G base stations. No administrative licence granted by an authority will be needed for the construction or deployment of a 5G base station in a sub-region, unless otherwise required by reasons related to either general safety or the protection of buildings or areas with valuable architecture, history or nature.

[40] FCCA decision on TeliaSonera DNA joint venture published 5 November 2015 (original decision in Finnish). KKY, 5 November 2015. Available at https://www.kkv.fi/globalassets/kkv-suomi/ratkaisut-aloitteet-lausunnot/ratkaisut/kilpailuasiat/2015/kielto--sitoumus--ja-toimitusvelvoiteratkaisut/r-2014-00-0438.pdf

[41] Telia Company, 1 February 2021, Telia and DNA o build more networks together, accelarating 5G roll-out in Finland. Available at: https://www.teliacompany.com/en/news/news-articles/2020/telia-and-dna-to-build-more-networks-together-accelerating-5g-roll-out-in-finland/

[42] Yhteisverkko, 2021, The Shared Network offers speed, better reception and services.

[43] Links to MNOs' speed tests are linked on Traficom website. Traficom, 2021, "Test your actual connection speed." Available (in Finnish)at: https://www.traficom.fi/en/communications/broadband-and-telephone/factors-affecting-speed-and-quality-internet-connection

[44] Traficom, 2021, The Bittimittari.fi Project. Available at: https://www.traficom.fi/en/bittimittari-project

[45] Traficom, 2021, "Monitor – Information about serviced in your area." Available at: https://www.traficom.fi/fi/asioi-kanssamme/monitori-tietoa-lahialueesi-palveluista

2.4.3.6 Switch-off of 2G and 3G networks

Telia is planning to shut down its 3G network by the end of 2023. The operator indicated that phones and subscriptions using 3G will keep running on the GSM network after decommissioning its 3G network and that the company will support its customers to upgrade to services with VoLTE and Wi-Fi calls during the transition.[46] Elisa is also expecting its 3G network to cease by the end of 2023,[47] and it is likely that DNA will follow its competitors' move to re-farm frequencies used by 3G network to its 4G network. However, there is no clear indication on future 2G switch-off at present.

2.4.3.7 Supporting local 4G/5G networks

The provision of mobile network services usually requires a network licence. The new legislation that entered into force at the beginning of 2021 has lightened licensing procedures for local mobile networks,[48] These minor public telecommunications networks can operate on the basis of a radio licence granted by Traficom without any separate network licence. Radio licences are granted for local public telecommunications networks in accordance with preconditions prescribed by law on a case-by-case basis. When considering the granting of a radio licence, the local and minor scope of operations will be assessed on the basis of the area of use, planned services and the number of subscriptions.

The 2300–2320 MHz and 24.25–25.1 GHz bands are available to local 4G/5G networks with Traficom's radio licence. It is possible that these licences could help further improve the quality of broadband services for local communities in the future.

2.4.4 Service pricing

Mobile service prices in Finland are generally lower than other advanced markets. A European Commission study on broadband prices reveals that the differential between the low use (0.5 GB) and high use (20 GB) baskets (individual handheld, offering data and voice calls) is smaller in Finland than the EU average and the US as shown in Figure 2.16 below.[49] The medium use (2 GB) baskets in Finland are similar in price to very high use (20 GB) baskets which may explain the very high monthly mobile data consumption.

Figure 2.16: Comparison of selected mobile baskets in Finland, 2019 (EUR PPP)

Basket (individual handheld)	Finland	EU27	US
0.5 GB mobile data, 30 calls	7.86	10.38	36.50
2 GB mobile data, 100 calls	15.20	15.87	46.50
20 GB mobile data with 100 calls	15.20	31.51	67.79

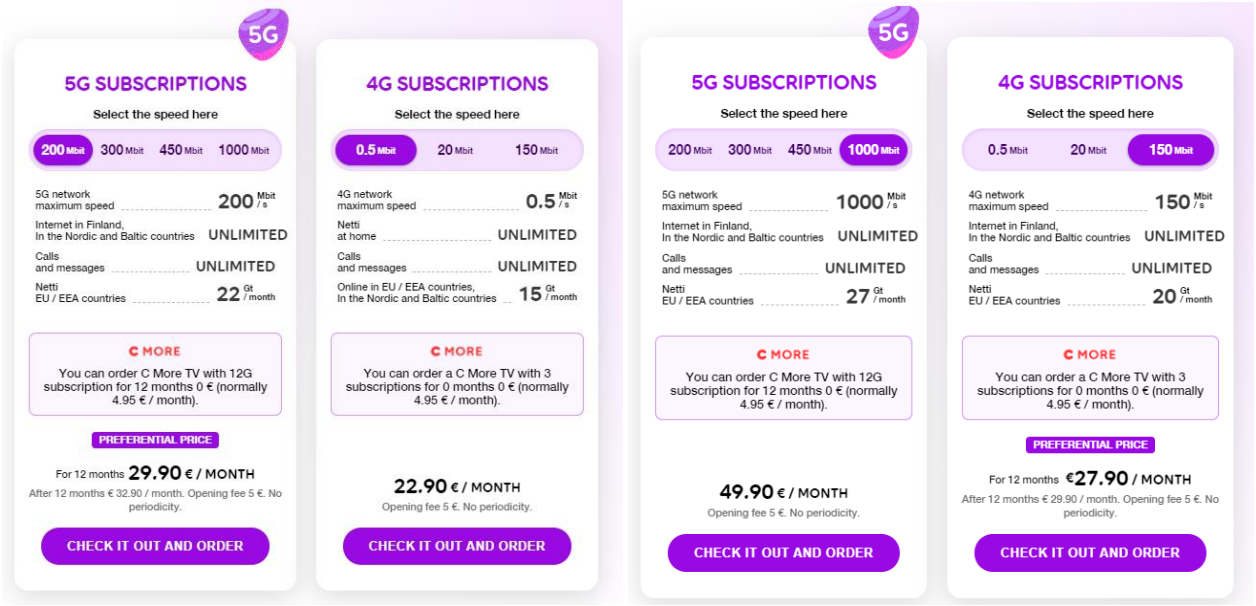
Note: Based on least expensive offers in each market.
Source: European Commission

[46] Telecompaper, 1 February 2021, DNA and Telia Finland extend shared network, Telia plans 3G shutdown in 2023. Available at: https://www.telecompaper.com/news/dna-and-telia-finland-extend-shared-network-telia-plans-3g-shutdown-in-2023--1370663
[47] ComputerWeekly, 12 March 2020, Elisa to pull plug on 3G network in 2023. Available at: https://www.computerweekly.com/news/252479963/Elisa-to-pull-plug-on-3G-network-in-2023
[48] Traficom, 2021, Local 4G/5G networks. Available at: https://www.traficom.fi/en/communications/communications-networks/local-4g5g-networks?toggle=Application%20procedure%20for%20frequency%20reservations%20and%20radio%20licences&toggle=Validity%20of%20a%20frequency%20reservation%20and%20radio%20licence
[49] Empirica and TÜV Rheinland, 2020, Mobile and Fixed Broadband Prices in Europe 2019. Study for European Commission. Available at https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=72471

Maximum network speeds are listed as a feature of the MNOs mobile broadband tariffs along with allowances for data, calls, messages and applicable international roaming caps.[50] The 4G and 5G packages tend to have unlimited data allowance with prices being differentiated by features of maximum download speeds and EU data roaming allowance. This is rather unlike many developed markets where users are restricted by monthly data allowances and unlimited plans tend to be costly.

In Finland, high data usage is actively encouraged. Unlimited data plans have become the norm in recent years, with pricing based on network data rates rather than bandwidth consumed.[51] For example, Telia allows consumers to select the maximum internet speed when selecting their mobile broadband package with price adjustment whereas DNA specifies the speeds as part of the tariff. Telia's lowest speed 5G subscription offers 200 Mbps for €29.90 per month, which is significantly lower than its highest speed 100 Mbps 5G offer for €49.90 per month. Higher speed packages are reflected through higher prices, though the diminishing cost applies as shown in Figure 2.17 below.

Figure 2.17: Telia 5G and 4G subscription prices, lowest speed (left) vs highest speed (right)



Source: Telia.fi (accessed 7 September 2021) https://kauppa.telia.fi/yksityisille/tuotteet/puhelinliittymat.aspx

2.4.5 Appraisal

In Finland, the provision of high quality networks, appear to result from both market factors and spectrum policy. The market structure is well-established with three MNOs within a small market of 5.5 million and market shares have been stable for the last 10 years.

Early access to key spectrum bands (e.g. 1800 MHz and 2.6 GHz for 4G, and 3.5 GHz for 5G) was a key factor in enabling early deployment and access by consumers to high quality mobile services. There is also a generally conducive environment for network investment with low spectrum prices and a permissive regime for network and spectrum sharing in more rural parts of Finland.

[50] It is common for operators to not impose roaming charges or allowances when using mobile broadband in other Nordic or Baltic countries and roaming allowances will be listed for EU/EEA countries as part of tariff features.

[51] Bell, 2 March 2020, Finns lead the way in mobile data usage. Available at https://blog.telegeography.com/finns-lead-the-way-in-mobile-data-usage

Tiered speeds are a key feature of mobile tariffs as mobile operators compete on both quality and price, with network speeds also being a key determinant of price-level for equivalent packages. Prices, including for high use mobile plans, are low compared to other advanced markets.

The popularity of unlimited data packages has driven high data usage, partly resulting in a larger proportion of households using mobile broadband only connections at home. Traficom has included obligations on sub-1 GHz spectrum requiring MNOs to provide 'reasonable indoor coverage'.

Each MNO publishes coverage maps and information on available speeds, and Traficom is introducing an independent speed/QoS monitoring service based on crowdsourced data for consumers.

2.5 Japan

Motivation for selection: Four MNOs are internationally leading operators for network performance and user experience. Close monitoring of spectrum usage and network technologies by government ensures high quality networks are deployed.

Key market & supply chain features	
Mobile network operators (subscriber share)	KDDI (40-45%), NTT Docomo (32-37%), SoftBank (18-23%), Rakuten Mobile (1-3%) (2021 Q2)
Mobile virtual network operators	85 MVNOs. Significant MVNOs include: mineo, OCN Mobile One, BIGLOBE, LINE Mobile[52]
Other notable players in broadband supply chain	KDDI, NTT Docomo (NTT East and NTT West) and SoftBank are also fixed ISPs. FTTP continues to gain market share in fixed broadband segment as DSL is phased out.
LTE coverage (% population)	99.9% (2021 Q2)
5G coverage (% population)	48.2% (2021 Q2)
Data speeds (average download & upload) – LTE	48.4 Mbps download, 9.4 Mbps upload (2021 Q1)
Network availability – LTE	98% to 99.7% - varies by operator (2021 Q1)
Sub-6 GHz assigned for MNOs	1370 MHz
Sub-1 GHz assigned for MNOs	150 MHz
Total cells, excluding 5G (thousands)	1,545
Total cells / 000' pop	12.3
Total cells / sq.km	4.24
Population (million)	125.84 (2020)
Rural population (%)	8.2% (2020)
Land Area (sq.km)	364,500 (2020)
GDP per capita (US$, current)	US$ 40,113 (2020)
Mobile broadband penetration (%)	206.4% (2020)
Mobile data usage (GB/month/sub)	5.54 GB (2020 Q3)

Source: Plum, GSMA Intelligence (2021 Q2), analysis by Opensignal (2021 Q1 values), World Bank (2020 values), ITU (2020), OECD (2019), MIC (2020 Q3), OpenCellid (October 2021)

2.5.1 Market overview and key players

There are three established MNOs and one recent entrant in the Japanese mobile market – lead MNO KDDI (mobile brand *au*), NTT Docomo, SoftBank, and MNO entrant Rakuten Mobile. Figure 2.18 shows the change in market share by subscriptions over the last six years. KDDI has overtaken NTT Docomo as the largest MNO by total number of connections in recent years. SoftBank's market share has also declined slightly over the period.

[52] Source: GSMA Intelligence and Statista. https://www.statista.com/statistics/1238041/japan-most-commonly-used-mvno/

Figure 2.18: Market shares by subscribers (2015 vs 2021)

Operator	Market share in Q2 2015	Market share in Q2 2021
KDDI	30 – 35%	40 – 45%
NTT Docomo	38 – 43%	32 – 37%
Soft Bank	23 – 27%	18 – 22%
Rakuten	Not applicable – yet to launch as MNO	1 – 3%

Source: GSMA Intelligence

The parent companies of the three established MNOs each own fixed telecommunications companies, that provide consumer and business services, as well as other digital and media businesses.[53] As an offshoot from e-commerce and online services of Rakuten Group, Rakuten Mobile first entered the Japanese market as an MVNO in October 2014, offering low-cost voice and data services, and launched as a full MNO on 8 April 2020. It relied on KDDI capacity in order to offer national coverage to support rollout of its own 4G network.[54] Rakuten's launch as an MNO was managed by MIC through a licence application process for new spectrum released in 1.7 GHz and 3.4 GHz bands in 2017-18.[55] All four MNOs have launched 5G services.[56]

Rakuten has the potential to be a disruptive player, as evidenced through price competition in the market since its entry, and its infrastructure sharing arrangements with utility companies to support 4G rollout (discussed further in Sections 2.5.3.3 and 2.5.4). Rakuten is also taking an innovative approach to 5G through Open RAN (further discussed in Section 4.8.2).

There are more than 80 MVNOs currently active in Japan, which includes 10 MNO sub-brands.[57] These MVNOs are supported by the three established MNOs and UQ Communications, a company specialising in provision of WiMAX services.[58] As of 2021 Q1, there were over 25 million MVNO subscribers which accounted for approximately 13.5% share of the mobile market.[59]

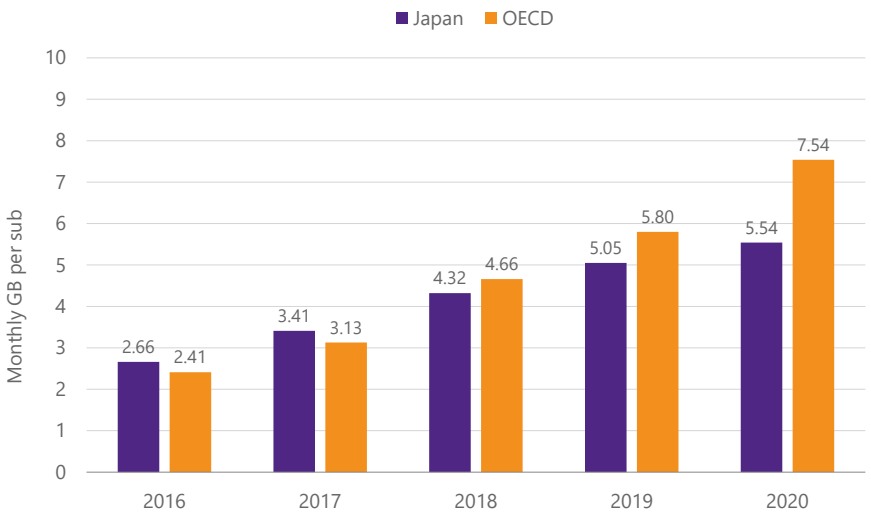
A further consideration is Japan's wide deployment of fibre. FTTH household coverage in Japan is over 99%. This has also contributed to the availability of fibre backhaul to support mobile network performance and, along with high prices for mobile services, contributed to offloading onto Wi-Fi networks. These factors will improve mobile experience by offering better capacity and reducing data traffic over mobile networks.

2.5.2 Network performance and usage

Japan ranks lower in terms of monthly mobile data consumption per user than the OECD average.[60] While mobile data usage has increased by more than two-fold between 2016 and 2020, the rate of growth has been lower than that seen in many international comparators.

[53] For example, SoftBank Group includes data centre company IDC Frontier, publishing company SB Creative, and gaming company GungHo Online.
[54] Telegeography, 8 April 2020, Rakuten Mobile launches low-cost mobile plans in Japan. Available at: https://www.commsupdate.com/articles/2020/04/08/rakuten-mobile-launches-low-cost-mobile-plans-in-japan/
[55] Telegeography, 9 April 2018, MIC advisory panel gives green light to Rakuten's mobile bid. Available at: https://www.commsupdate.com/articles/2018/04/09/mic-advisory-panel-gives-green-light-to-rakutens-mobile-bid/
[56] GlobeNewswire, 10 June 2020, Japan's four MNOs all launch 5g. Available at: https://www.globenewswire.com/news-release/2020/06/10/2046351/0/en/Japan-s-four-MNOs-all-launch-5G.html
[57] This includes three KDDI sub-brand MVNOs, four NTT sub-brands, two SoftBank, and mineo. Source: GSMA Intelligence, 2021.
[58] UQ Communications uses 2.6 GHz TDD to provide its WiMAX2+ services.
[59] MIC, March 2021, "Publication of quarterly data on number of telecommunications service contracts and market share." Available (in Japanese) at: https://www.soumu.go.jp/menu_news/s-news/01kiban04_02000187.html
[60] OECD, 2021, Broadband Portal – Penetration and data usage. Available at: https://www.oecd.org/digital/broadband/broadband-statistics/ Statistics: Mobile data usage per mobile broadband subscription.

Figure 2.19: Mobile data usage trends – Japan vs OECD



Source: Plum analysis, MIC (spectrum awarded and data usage for 2020), OECD (data usage; 2019 latest reported).

Figure 2.20 illustrates the most popular apps by monthly usage, with 75.3% of internet users using mobile chat messaging apps, 74.7% using social media apps and 58.1% using entertainment and video apps.

Figure 2.20: Monthly app use among internet users (16-64 years) in Japan (2020)

Type of mobile app	Percentage of internet users 16-64 years
Chat (messengers)	75.3%
Social networking	74.7%
Entertainment and video	58.1%
Music	34.0%
Games	39.2%
Shopping	48.4%
Map	56.5%
Banking and financial services	24.7%
Health, fitness and nutrition	12.9%
Dating and friendship	3.9%

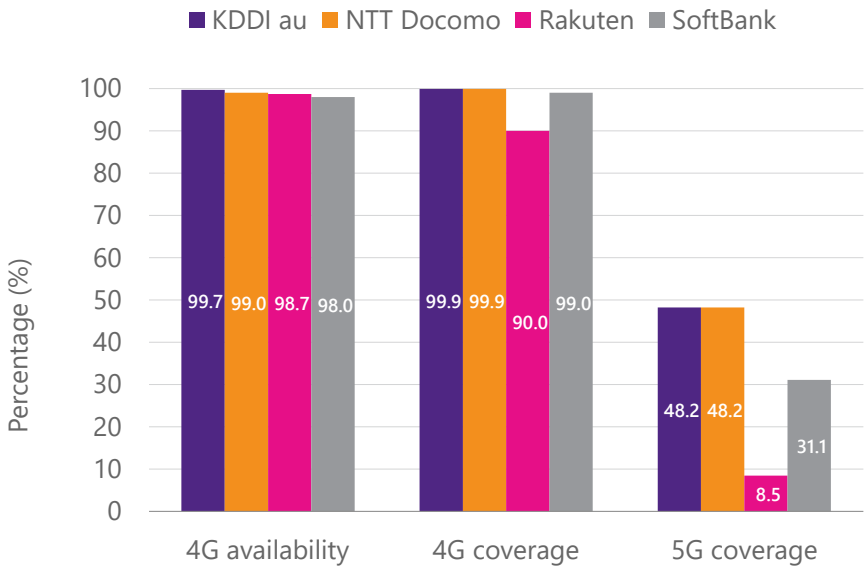
Source: GlobalWebIndex

As of 2020 4G coverage in Japan is at 99.9% of population.[61] Figure 2.21 reports 4G and 5G network coverage by population and 4G availability metric (percentage of time users can connect to the 4G network). KDDI is the lead operator for availability and tied with NTT Docomo for network coverage. Although entrant Rakuten reports the lowest network coverage, it scores higher than SoftBank on 4G availability.

[61] Source: GSMA Intelligence, 2021.

All four Japanese operators scored amongst the global leaders for 4G availability along with 14 other MNOs from South Korea, the Netherlands and the USA amongst others.[62]

Figure 2.21: Network performance – 4G availability (% time accessible) and 4G/5G coverage (% population)



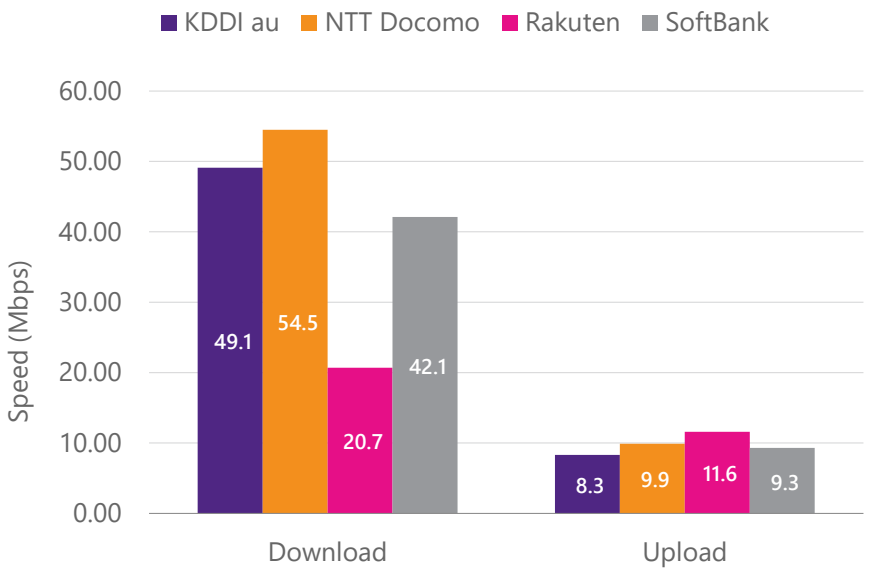
Source: Opensignal (April 2021; 4G availability), GSMA Intelligence (June 2021; 4G population coverage, 5G population coverage)

In terms of network experience and performance, all four of Japan's mobile networks score highly in Opensignal's international comparisons. Users of SoftBank ranked first internationally for the best video experience and gaming experience in Opensignal's Mobile Network Experience 2021 report (joint first place with T-Mobile Netherlands).[63]

Figure 2.22 shows average download and upload speeds as reported by Opensignal in April 2021.[64] NTT Docomo users experienced the highest download speeds and second highest upload speeds. Rakuten users experienced the lowest download speed though upload speed was higher than the other three MNOs. Rakuten's lower performance is likely to be due to its relative lack of LTE spectrum – it has only holdings in the 1800 MHz band compared to the other three MNOs and its 5G deployment is still at an early stage.

[62] Opensignal, March 2021, Global Mobile Network Experience Awards 2021. Available at: https://www.Opensignal.com/sites/Opensignal-com/files/data/reports/pdf-only/data-2021-03/Opensignalglobalmobilenetworkexperienceawardsmarch2021.pdf
[63] Opensignal, March 2021, Global Mobile Network Experience Awards 2021.
[64] Opensignal, April 2021, Japan Mobile Network Experience Report – April 2021. Available at: https://www.Opensignal.com/reports/2021/04/japan/mobile-network-experience

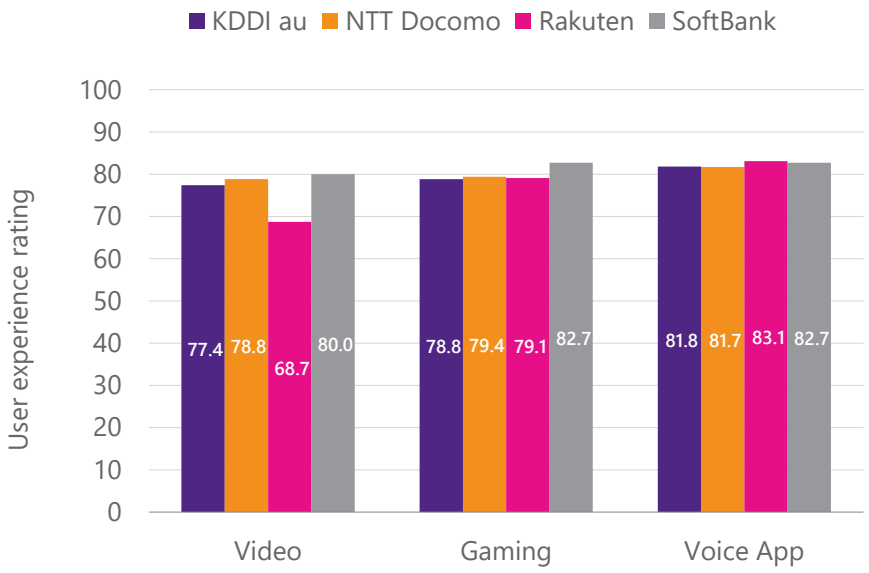
Figure 2.22: Network performance – overall download and upload speed (2021)



Source: Opensignal (April 2021)

Figure 2.23 reports Opensignal's metrics for video experience, gaming experience, and (OTT) voice app experience. These metrics are based on analysis of various experience measures – see Appendix B for more details on the scoring criteria.[65] SoftBank provides the highest video and gaming experience with a notably higher score than rival MNOs even though it measures third in the majority of the network performance measures above. Rakuten's video performance is the lowest among the four MNOs.

Figure 2.23: User experience score, of 100 (2021)



Source: Opensignal (April 2021)

[65] Further details on Opensignal's methodology for each user experience score is available on their website: https://www.Opensignal.com/methodology-overview

In terms of 5G performance, Opensignal reports that Tokyo is the fifth highest performing city in terms of 5G download and upload speeds (277.5 Mbps download, 21.9 Mbps upload)[66] and Japan overall ranks second for 5G peak download speed (856.5 Mbps).[67] Although Japan is a strong performer across all 5G user experience metrics – 5G video experience, 5G games experience, and 5G voice app experience – it does not figure in the top 10 international performers for network speeds. Compared to some leading markets (e.g. South Korea, US) which launched 5G in 2019, 5G was only launched in Japan in late March 2020 and pressure to reduce prices (see Section 2.5.3.2) may have contributed to slower pace of 5G investment. The pace of deployment has picked up since the start of 2021.[68]

2.5.3 Policy and regulatory environment

In Japan, the Ministry of Internal Affairs and Communications (MIC) is responsible for overseeing the supply of telecommunications services in accordance with the following Acts:[69]

- *The Telecommunication Business Act* (the Telecom Act), which outlines requirements on telecommunications services and network providers and sets out access requirements. The Telecom Act also outlines registration and notification requirements and a number of disclosure and reporting obligations.

- *The Radio Act*, which outlines the regulations associated with radio frequency assignment and licensing, use of radio equipment and other obligations associated with spectrum management. The Radio Act was amended in April 2020 in order to implement a system for spectrum sharing based on flexible location and timing, referred to as the Dynamic Spectrum Sharing System.[70]

- *The Wire Telecommunications Act*, which sets out the requirements on fixed network operators and service providers.

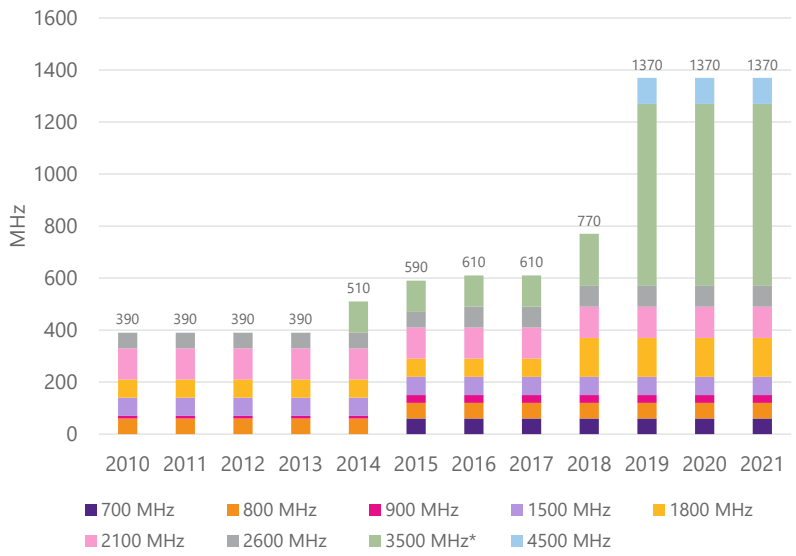
As noted in the previous sections, the Japanese government has implemented several pro-competition policies in the retail mobile market and enable high-levels of fixed broadband coverage and quality. Several key policies affecting relevant consumer and competitive outcomes are highlighted below.

2.5.3.1 Spectrum policy and management

Currently the four MNOs have been assigned 1370 MHz of spectrum in the frequencies below 6 GHz as shown in Figure 2.24. Another 1600 MHz of mm-wave spectrum in the 26/28 GHz bands has also been assigned for IMT use.

[66] 5G global top city for rank as Jeonju, South Korea (1st), Hsinchu City, Taiwan (2nd), Riyadh, KSA (3rd), Dubai, USE (4th) and Tokyo, Japan (5th).
[67] Opensignal, 15 April 2021, Benchmarking the Global 5G Experience – April 2021. Available at: https://www.Opensignal.com/2021/04/15/benchmarking-the-global-5g-experience-april-2021
[68] Opensignal, 19 August 2021, Japan is starting to close the gap with global 5G leaders. Available at: https://www.Opensignal.com/2021/08/19/japan-is-starting-to-close-the-gap-with-global-5g-leaders
[69] Lexology, 2021, In brief: telecoms regulation in Japan - Lexology. Available at: https://www.lexology.com/library/detail.aspx?g=d581c9e6-e02d-4e72-92d2-2db75295ff92Available at:
[70] CMS, 2021, 5G Regulation and Law in Japan. Available at: https://cms.law/en/int/expert-guides/cms-expert-guide-to-5g-regulation-and-law/japan

Figure 2.24: Sub-6 GHz spectrum assigned for mobile services in Japan



Notes: * The 3500 MHz band ranges from 3400-4100 MHz in Japan. Spectrum set aside for private networks not included.
Source: APT, national regulator, Plum analysis

Spectrum in Japan is assigned administratively by the MIC. The most recent award involving 5G frequencies in 3.6-4.1 GHz, 4.5 GHz and 28 GHz bands was a beauty contest in April 2019.[71] The 5G spectrum licences were finalised in July 2019. The MIC also retained some frequencies (e.g., 4.6-4.9 GHz, 28.2-29.1 GHz) for local licensing of private 5G networks. For 5G spectrum licences, MNOs are required to comply with the following minimum standards:[72]

- Nationwide coverage of 5G infrastructure must exceed 50% and services must be available in each prefecture within two years.
- Provision to maintain safe and reliable telecommunication equipment necessary for the operation of a specific base station.
- Funding to cover necessary costs and a plan to provide MVNO access; and
- Agreement that their business will not be transferred to other operators.

As part of the 5G award, MNOs are subject to conditions for efficient use of spectrum that specifies technology deployment. For 5G, MNOs are required to use "*technology to form and control one or more directional beam patterns using multiple antennas, phasers and amplifiers, time division multiplexing, 256QAM, carrier aggregation technology and other technologies to ensure efficient use of radio waves*".[73] Similar technology obligations associated with efficient use of spectrum apply to MNOs' LTE spectrum assignments and networks and are reflected in the MIC's spectrum monitoring conditions.

As the spectrum management authority, an integral part of the MIC's work is the continuous monitoring of spectrum use by the MNOs. The periodic monitoring also serves as a way to assess operators' performance and

[71] PolicyTracker, 16 April 2019, Japan Assigns 5G Spectrum for 14.5 billion. Available at: https://www.policytracker.com/japan-assigns-5g-spectrum-for-14-5-billion/
[72] CMS, 2021, 5G Regulation and Law in Japan.
[73] MIC, December 2018, "For the introduction of 5G mobile communications systems – about guidelines for opening specific base stations." Refer to slide 12. Available (in Japanese) at: https://www.soumu.go.jp/main_content/000589764.pdf

evaluate progress on network rollout of advanced protocols such as MIMO and carrier aggregation. The MIC also review operator modulation techniques. The emphasis is more on technology deployment (e.g., number of base stations and use of advance protocols) rather than the outcome of the technology deployment (i.e., the direct QoS measures).

The MIC started its three-yearly spectrum survey in 2003 for frequencies above 3.4GHz. In the following year, another survey was undertaken for frequencies between 770MHz and 3.4GHz.[74] The last survey in the series was carried out in 2005 for frequencies below 770MHz. This cycle was repeated until 2020, when a revision was made to the schedule. There would instead be two surveys in the cycle: the first for frequencies up to 714MHz, and the second for frequencies above 714MHz.[75]

Information gathered through the survey includes the number of radio stations, the specific usage of radio stations, and the possibility of substitution for other modes of telecommunications as well as plans for effective use of radio waves and frequency transition. The survey is conducted for both licensed and unlicensed spectrum across 11 locations nationwide.[76] A survey form is sent to the licensee with a request for response, and an analysis is carried out on the data entered into the radio station supervision database (a comprehensive radio station management file). Additionally, the survey results of the radio wave emission status are used to supplement the survey where appropriate.

An evaluation of the survey results then follows. This evaluation is undertaken based on compliance with conditions under which access to the radio frequencies are granted, including the effective use of radio waves. Important factors that are considered to determine the degree of effective use of the spectrum are as follows:

- Development of radio communication technologies.
- Trends in demand for new technology platforms that use the radio waves; and
- International trends in frequency allocation.

Usage of spectrum is evaluated for individual frequency bands as well as across multiple frequency bands. There are two main assessment areas – coverage (assessed according to the number of base stations deployed, population coverage and geographic coverage) and the introduction of technology that contributes to an improvement in service performance (e.g., speed). Operators are evaluated based on the technologies deployed in both their initial and later rollout phases. To meet the highest assessment criteria (Grade S) for initial rollout of frequency bands, operators' deploying multiple technologies must exceed 50% of the network for the following standards.

- LTE / 4G or advanced BWA standard: CA, 4MIMO, 256QAM
- NR standard: CA, 4/8 MIMO, Massive MIMO, 256QAM

The evaluation of survey results are published for public consultation which includes various parameters, such as transmission activity by time of day, average busy-hour traffic, operation areas, and annual operation period amongst others.

In addition to the general survey described above, a usage status survey of radio spectrum assigned to mobile and broadband wireless access (BWA) is also conducted. This is a result of the revision to the *Radio Law* in 2017.

[74] From 2012, the lower end of the range was changed to 714MHz, and subsequent survey in the cycle would be undertaken for frequencies below 714MHz.
[75] MIC, May 2020, "2019 Evaluation result of radio wave usage survey (draft) – frequency band about 714 MHz and below 3.4 GHz." Available (in Japanese) at: https://www.soumu.go.jp/main_content/000689841.pdf
[76] These 11 locations nationwide are drawn from Article 4 of the Ordinance of the Ministry of Investigation and include Hokkaido, Tohoku, Kanto, Shinetsu, Hokuriku, Tokai, Kinki, Chugoku, Shikoku, Kyushu and Okinawa.

The survey is motivated by the need to better understand the situation specific to national mobile and BWA usage, against the background of rapidly rising numbers of wireless stations for all spectrum uses. This additional mobile and BWA survey is conducted annually from 2018.[77]

The MIC's regular spectrum monitoring contributes to efficient usage of spectrum frequencies and delivery of high quality networks by operators, as well as identification of future frequencies and their availability to meet forthcoming spectrum demand for mobile and BWA services.

2.5.3.2 Measures to promote competition

The MIC and the Japan Fair Trade Commission (JFTC) have been seeking to promote competition in the mobile market for a number of years.[78] A series of consolidations in the early 2010s had led to concerns over lack of competition and high prices in addition to perceptions of lower 5G readiness than China, South Korea and the US.[79]

The MIC and JFTC have taken a number of measures to promote retail level competition, such as facilitating Rakuten Mobile's entry as the fourth MNO and attempts to restrict handset subsidies offered as part of post-paid plans.[80] The MIC has also implemented several policies to improve the competitive dynamics of the mobile market. These include introduction of measures such as mandatory SIM unlocking, ending autorenewal of two-year contracts, and introducing a requirement for MNOs to write to subscribers and set out the new terms of service beyond the contract period. The MIC also launched a consumer site that provides advice to encourage mobile switching and compares plans. This compares data and voice allowances of packages.[81]

There has also been growing focus on the role of the MVNO market to enhance competition and to ensure that MNOs do not discriminate between affiliated (sub-brand) MVNOs in terms of service provision. In October 2018, the MIC established new regulations prohibiting MNOs from discriminating between different MVNOs in terms of data speeds. In December 2019, MIC issued a request for MNOs to open their 5G networks to MVNOs.[82] This required MNOs, when launching their own services, to promptly provide MVNOs with the necessary information relating to their services (e.g., timing of network launch, service areas, network speed, connection fees and technological details for connection), and to ensure that this was done in a timely manner to accommodate discussion between MNO and MVNO parties.[83]

2.5.3.3 Network sharing

In April 2020, SoftBank and KDDI announced the establishment of joint venture 5G JAPAN,[84] which intends to promote rapid build-out of 5G networks in rural areas. This will rely on infrastructure sharing based on the mutual use of SoftBank and KDDI's base station assets as well as building new 5G base stations and supporting

[77] MIC, 2020, "Related to mobile phones and national BWA – Evaluation results of radio wave usage survey December 2019." Available (in Japanese) at: https://www.soumu.go.jp/main_content/000738096.pdf
[78] Progressive Policy Institute (PPP), July 2018, An Economic Analysis of Japan's Current Mobile Communication Policy from the Competition and Innovation Perspective. Available at: https://www.progressivepolicy.org/wp-content/uploads/2018/07/PPI_JapanMobile_2018.pdf
[79] Japan was classed as 4th internationally for 5G readiness according to CTIA's 5G Readiness Index, though its performance rank was closer to UK (5th rank), Germany (joint 5th) and France (6th). Source: CTIA, April 2018 "The Global Race to 5G."
[80] PPI (2018) notes that efforts to restrict subsidies had only marginal success as the communication services fees themselves have not substantially decreased and mobile prices declined by only 10% between 2016 and 2018 in comparison to a 25% decline observed in the US.
[81] MIC, 2021, "Can you choose the price plan that suits you?" consumer information site. Available (in Japanese) at: https://www.soumu.go.jp/menu_seisaku/ictseisaku/keitai_portal/index.html
[82] MIC, 18 December 2019, Request for Opening of Functions related to Provision of 5G Services to MVNO. Available at: https://www.soumu.go.jp/main_sosiki/joho_tsusin/eng/pressrelease/2019/12/18_4.html
[83] CMS, 2021, 5G Regulation and Law in Japan.
[84] 5G JAPAN, 2021. Available at: https://www.5g-japan.co.jp/

infrastructure to promote regional expansion of 5G.[85] In June 2021, Ericsson announced that it has delivered Japan's first Multi-Operator Radio Access Network (MORAN) to KDDI and SoftBank, capable of 5G radios.[86]

Joint ownership and/or usage of network infrastructure is permitted at the discretion of the MNO, though there is no obligation to share mobile infrastructure with other MNOs.[87] The MIC has previously promoted infrastructure sharing, primarily to share towers as a result of regulations regarding exterior appearance, which would limit construction of multiple towers. Mobile infrastructure sharing has been practiced in Japan since at least 2015. This has included both passive and active sharing (though the extent to which is unclear) and has been driven by both regulatory and commercial agreements.

Three of the MNOs – KKDI, SoftBank and Rakuten Mobile – are collaborating with TEPCO (Tokyo Electric Power Company) Power Grid in trials of base station sites and equipment sharing using TEPCO's utility poles and other electric power infrastructure to support trials in 2019.[88] In 2018, Rakuten signed an agreement with utility company Kansai Electric Power Co. to use the latter's transmission towers, utility poles, telecom towers and other facilities, to support roll out of its 4G network and also had similar agreements in place with Chubu Electric Power and TEPCO.[89]

2.5.3.4 Pricing regulation

Prices for mobile services must be submitted by the MNOs to the MIC for review before implementation.[90] Under the *Telecommunications Business Act*, mobile pricing restrictions apply to the three larger MNOs. If the MIC finds a proposed tariff to be inappropriate on the grounds that it is anticompetitive or otherwise significantly unreasonable, the MNOs are obligated to review and change the proposed tariff. If the proposed tariff is accepted, this price is charged to end users and the other terms of service are not regulated. In practice, most tariffs are approved. It is not clear if this requirement also extends to Rakuten Mobile or MVNO price offers.

In September 2020, the Japanese government announced its intention to make mobile services from NTT Docomo, KDDI au and SoftBank more affordable and align persistent high prices with other developed markets (this policy was part of former PM Yoshihide's election campaign).[91,92] It was reported in December 2020 that both NTT Docomo and SoftBank had agreed to lower their mobile data fees.[93]

It is not possible to assess whether the (lack of) pricing restrictions and persistent high prices, and resulting margins, has contributed to or resulted from the MNOs delivery of high quality networks given the limited available information.

[85] SoftBank, 1 April 2020, SoftBank Corp and KDDI Corporation Establish Joint Venture to Promote the Rapid Build-out of 5G Networks in Japan's Rural Areas. Available at: https://www.softbank.jp/en/corp/news/press/sbkk/2020/20200401_01/

[86] Ericsson, 23 June 2021, Ericsson sets up Japan's first multi-operator RAN with KDDI and SoftBank. Available at: https://www.ericsson.com/en/press-releases/2021/6/ericsson-sets-up-japans-first-multi-operator-ran-with-kddi-and-softbank

[87] Mizuho Industry Focus, 30 November 2010, Vol.91, Chapter 4, page 34. Available at: https://www.mizuhogroup.com/binaries/content/assets/pdf/mizuho-bank/insights/industry/mif_91.pdf

[88] The 3G4G Blog, 27 March 2019, Mobile Network Infrastructure Sharing in Japan over Electric Power Infrastructure. Available at: https://blog.3g4g.co.uk/2019/03/mobile-network-infrastructure-sharing.html

[89] Telegeography, 4 April 2018, Rakuten inks deal to use Kansai Electric's facilities to support new 4G network. Available at: https://www.commsupdate.com/articles/2018/04/04/rakuten-inks-deal-to-use-kansai-electrics-facilities-to-support-new-4g-network/

[90] The Law Reviews, December 2019, The Technology, Media and Telecommunications Review – tenth edition. Refer to page 148. Available at: https://www.lw.com/thoughtLeadership/technology-media-telecommunications-review-japan-latham-2020

[91] TelecomTV, 29 September 2020, That was quick: two weeks in and Japan's new tariff-cutting PM is causing panic. Available at: https://www.telecomtv.com/content/mobile/that-was-quick-two-weeks-in-and-japan-s-new-tariff-cutting-pm-is-causing-panic-39781/

[92] The Economist, 8 October 2020, Dialling down: Japan's cosy telecoms firms are being told to lower prices. Available at: https://www.economist.com/business/2020/10/08/japans-cosy-telecoms-firms-are-being-told-to-lower-prices

[93] Reuters, 22 December 2020, Japan telco SoftBank bows to government pressure with fee cuts. Available at: https://www.reuters.com/article/softbank-carrier-fees-idUSL1N2J2029

2.5.3.5 Switch-off of 2G and 3G networks

National 2G services were switched off in 2012.[94] NTT Docomo ceased its 2G (PDC)[95] services in January 2012, following respective closure of KDDI (CDMA) and SoftBank's (PDC) 2G networks in March 2008 and March 2010.[96] The closure of 2G was largely a market-led outcome rather than a result of government policy.[97]

All three established MNOs have announced their intention to close 3G networks in the coming years – KDDI by March 2022, SoftBank by January 2024, and NTT Docomo by March 2026.[98] New entrant operator Rakuten's own network only offers 4G and 5G services.

2.5.3.6 Tax incentives for 5G investment and tech start-ups

In 2020, the Japanese government introduced a number of tax reforms and incentives aimed at encouraging companies to invest in start-ups and 5G in order to stimulate economic growth.[99] In part, this was a move to compete internationally with China's advance in 5G technology and to encourage Japanese firms to invest their internal reserves (over 460 trillion yen or US$4.23 trillion).

The *2020 Tax Reform Act* introduced tax benefits to promote the introduction of 5G technology and use.[100] Accredited corporations were eligible to receive either a 30% special depreciation rate or a 15% tax credit on qualifying 5G investments (as outlined by the Act) from the enactment of the new Act (the '*Act to Promote Introduction of Specified Advanced Information Communication Systems*') through to 31 March 2022. Both MNOs and private network developers supporting smart factories or smart agriculture in rural areas are eligible.

The Japanese government also introduced a tax deduction for start-up investments equal to 25% of the capital investment for investments over 100 million yen, subject to an upper ceiling. Both domestic and foreign venture capital companies that are less than 10 years old are eligible under the Industrial Competitiveness Enhancement Law. There is limited public information on the uptake or impact of the tax incentive schemes in promoting 5G network rollout or start-up investment.

2.5.4 Service pricing

Mobile service prices in Japan are among some of the highest globally. Figure 2.25 compares the prices for selected baskets offering mobile data and voice calls in Japan, EU and the US. The prices in Japan are around twice those in the EU though the low and medium use baskets are slightly cheaper compared to the US. The differential between the low and high use baskets is also larger than those in the EU, the US, and the likes of Finland and Norway.

[94] Lexology, 2021, In brief: telecoms regulation in Japan. Available at: https://www.lexology.com/library/detail.aspx?g=d581c9e6-e02d-4e72-92d2-2db75295ff92
[95] Personal Digital Cellular (PDC) is a TDMA-based standard used exclusively in Japan.
[96] Telegeography, 17 January 2017, 2G is fading away but it might outlive 3G in Europe. Available at: https://blog.telegeography.com/2g-is-fading-away-but-it-might-outlive-3g-in-europe
[97] Mobile World Live, 5 July 2017, Blog: Who will be last in Asia to turn off 2G (or 3G)? Available at: https://www.mobileworldlive.com/blog/blog-who-will-be-the-last-to-turn-off-2g-or-3g
[98] EMnigy, 10 December 2020 (last updated 2 November 2021), Global 2G and 3G Phase Out/Sunset: What Do We Know So Far? Available at: https://www.emnify.com/en/resources/global-2g-phase-out
[99] Disruptive.asia, 13 December 2019, Japan reveals tax incentives to encourage local 5G investment. Available at: https://disruptive.asia/japan-tax-incentives-5g-investment/
[100] PWC, last reviewed 3 August 2021, Japan Corporate – Tax credits and incentives. Available at: https://taxsummaries.pwc.com/japan/corporate/tax-credits-and-incentives

Figure 2.25: Comparison of selected mobile baskets in Japan, 2019 (EUR PPP)

Basket (individual handheld)	Japan	EU27	US
0.5 GB mobile data, 30 calls	21.05	10.38	36.50
2 GB mobile data, 100 calls	31.98	15.87	46.50
20 GB mobile data with 100 calls	63.30	31.51	67.79

Note: Based on least expensive offers in each market.
Source: European Commission

Unlike Finland, connection speeds (quality) are not advertised as part of the Japanese MNOs retail offerings.[101] The key features of the mobile tariffs are allowances and charges for data, voice and SMS services. It is common for tariffs to be tiered; for example, to allow subscribers only to pay for how much data they have used or to incur a discount per additional MB on data consumed over a particular threshold.

The entry of Rakuten as a full MNO appears to have increased price competition with lower price plans being launched in efforts to capture larger market share, while the incumbents have also responded with their own discounted offers.[102,103]

2.5.5 Appraisal

In Japan, the main driver of high quality networks has been the MIC's supply-led approach to spectrum management. The highly planned and organised approach means that operators generally get the spectrum in advance of demand arising. For example, Japan has assigned 700 MHz across the 3.4-4.1 GHz range. Spectrum is administratively assigned but it comes with strict network deployment conditions. Rather than measuring network performance outcomes directly, this approach has delivered high quality of service by specifying the deployment of advanced network protocols and base station coverage in advance of demand arising.

In terms of infrastructure Japan was among the earliest to heavily invest in fibre rollout in the early 2000s which may have benefited mobile network rollout. While mobile networks are of high quality, this does not appear to have led to higher than average data usage in Japan compared to some OECD countries. This is partly due to high mobile prices and the wide availability of FTTH networks and Wi-Fi substitutes.

The Japanese government has also offered tax incentives to encourage 5G investment by MNOs and non-traditional network operators. The tax incentives were introduced along with other tax reforms, with the aim of supporting Japan as a recognised 5G leader – it is as yet unclear how effective these measures are in supporting high quality networks.

Competition has not been a key driver in delivering network quality. Japan's mobile market is characterised by high prices, and the government has paid a lot of attention to introducing pro-competition measures in an effort to reduce prices of mobile services. The three established MNOs have relatively stable market shares, though recent entrant Rakuten Mobile has the potential to be a disruptive player in the future, adopting a different commercial and technology model.

There is very little information in terms of consumer perception of quality or ability to exercise choice. Unlike Finland, network speeds are not a key feature within Japanese retail offers. Though the MIC spectrum

[101] Based on Plum survey of mobile operator retail websites.
[102] Kyodo News, 29 January 2021, Rakuten to offer lowest monthly large mobile data plan for 1,980 yen. Available at: https://english.kyodonews.net/news/2021/01/3aafb80ddb83-rakuten-to-offer-cell-phone-plans-with-up-to-1-gigabyte-free-data.html
[103] FierceWireless, 29 January 2021, Rakuten Mobile ratchets up wireless price war. Available at: https://www.fiercewireless.com/operators/rakuten-mobile-ratchets-up-wireless-price-war

monitoring does publicly report network quality measures, it is unclear whether this factors into consumer choice of mobile services.

2.6 Norway

Motivation for selection: Regulatory intervention to maintain effective competition and government policy has aimed to deliver high speed network coverage.

Key market & supply chain features	
Mobile network operators (subscriber share)	Telenor (43-48%), Telia (33-38%), ICE (10-15%), and others (<5%) (2021 Q2)
Mobile virtual network operators	24 MVNOs. Significant MVNOs include Dipper, MyCall, Talkmore, One Call, Lycamobile
Other notable players in broadband supply chain	Fixed ISPs includes Telenor (36.1% share), Telia (18.1%), Altibox (27.2%) and smaller players GlobalConnect, NexGenTel and others offering both FTTx, fixed wireless and mobile broadband (2019 subscriber shares)
LTE coverage (% population)	99% (2021 Q2)
5G coverage (% population)	33% (2021 Q2)
Data speeds (average download & upload) – LTE	60.6 Mbps download, 14.8 Mbps upload (2021 Q1)
Network availability – LTE	97.2% to 97.6% - varies by operator (2021 Q1)
Sub-6 GHz assigned for MNOs	1050MHz
Sub-1 GHz assigned for MNOs	190 MHz
Total cells, excluding 5G (thousands)	165.8
Total cells / 000' pop	30.8
Total cells / sq.km	0.45
Population (million)	5.38 (2020)
Rural population (%)	17.0 % (2020)
Land Area (sq.km)	365,108 (2020)
GDP per capita (US$, current)	US$ 67,294 (2020)
Mobile broadband penetration (%)	103.7% (2020)
Mobile data usage (GB/month/sub)	7.25 (2020)

Source: Plum, Nkom (Dec 2020), GSMA Intelligence (2021 Q2), analysis by Opensignal (2021 Q1 values), World Bank (2020 values), ITU (2020). OpenCellid (October 2021).

2.6.1 Market overview and key players

There are three main MNOs in the Norwegian market. Telenor is the lead operator in terms of subscribers, followed by Telia and ICE respectively.[104] ICE, previously a small operator offering wireless broadband services in the 450 MHz band acquired 800 MHz, 900 MHz and 1800 MHz spectrum at the 4G auction in 2013, which enabled it to become a credible competitor to Telenor and Telia, at the expense of Tele2.[105]

[104] Source: GSMA Intelligence, 2021.
[105] Tele2, which was then the third MNO in Norway, had failed to acquire any spectrum at the 4G auction.

The market share of ICE has increased over the last six years as shown in Figure 2.26. Telenor's market share has dropped by approximately 5% while Telia's market share has remained mostly stable, as shown below.[106]

Figure 2.26: Market shares by subscribers (2015 vs 2021)

Operator	Market share in Q2 2015	Market share in Q2 2021
Telenor	50 – 55%	45 – 50%
Telia	32 – 37%	33 – 38%
ICE	< 5%	10 – 15%
Others	~ 10%	~ 5%

Source: GSMA Intelligence

As of 2020, GSMA Intelligence reports a total of 24 MVNOs including four MNO sub-brands of Telenor and Telia. As of now ICE does not have any MVNO sub-brand. The service offerings of these MVNOs include data, voice, cellular M2M, business specific packages, along with heavily discounted deals.

Most of the MVNOs are hosted on Telenor and Telia's networks. ICE currently only supports cellular M2M services for one of the MVNOs.[107] Some key MVNOs include Fjordkraft Mobil, Chilimobil and Lycamobile. As of 2020, each of these held a mobile subscriber market share of 2%, 1.2% and 1.1% respectively.[108] A new player called Fjordkraft Mobil recently launched as a MVNO. Launched in April 2017, Fjordkraft has quickly doubled its subscriber base from 1.1% in 2018 to 2% in 2020. Fjordkraft is originally a Norwegian energy provider. In the mobile sector, its business model targets the customers through cheap bundled energy and mobile services. On its website, it advertises 'cheap mobile subscription' for those who purchase electricity from it.[109]

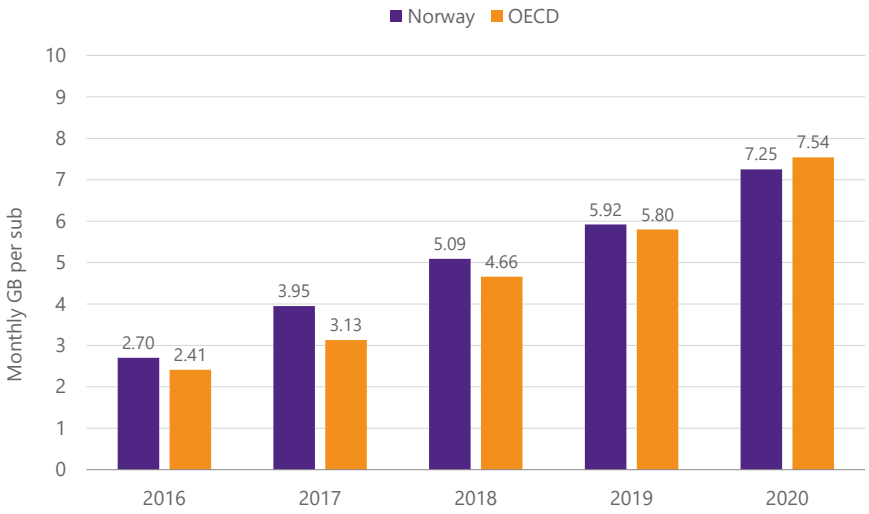
In the recent 5G auction for the 2.6 GHz and 3.5 GHz bands completed in September 2021, Altibox, a provider of fibre broadband and TV services, won spectrum in 50 MHz of 2.6 GHz TDD and 100 MHz of 3.5 GHz spectrum.[110] Altibox has said it would be using the spectrum initially for 5G-based fixed wireless services in places without fixed broadband and eventually for other 5G services.[111]

2.6.2 Network performance and usage

Norway's average monthly data consumption in 2020 was 7.25 GB per user as shown in Figure 2.27. This ranks 18th amongst 37 OECD countries (note, USA is excluded) and slightly below the 2020 OECD average of 7.54 GB. Norway's monthly consumption has increased by approximately 169% from 2.70 GB per user in 2016.[112]

[106] Ibid, NKOM, May 2021.
[107] Source: GSMA Intelligence, 2021, MVNO list.
[108] NKOM, The e-commerce market 1st half of 2020. Available at: https://ekomstatistikken.nkom.no/#/article/ekom1h2020#mobil_marked
[109] Fjordkraft, Cheap mobile subscription for everyone who has electricity from Fjordkraft. Available at: https://www.fjordkraftmobil.no/
[110] Nkom (30 September 2021). The Norwegian 5G auction has concluded. https://www.nkom.no/aktuelt/the-norwegian-5g-auction-has-concluded
[111] Altibox (30 September 2021). Altibox kjøper 5G-frekvenser. https://www.altibox.no/omaltibox/presse/
[112] OECD, 2021, Broadband Statistics. Available at: https://www.oecd.org/digital/broadband/broadband-statistics/ Statistics: Mobile data usage per mobile broadband subscription.

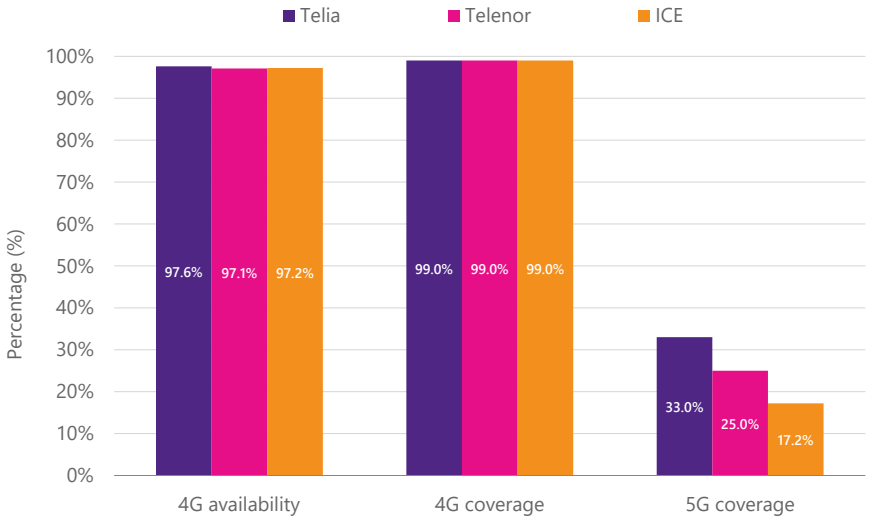
Figure 2.27: Mobile data usage trends – Norway vs OECD



Source: OECD, Plum analysis

As of 2020, the coverage of 4G in Norway is 99.9% of population.[113] Figure 2.28 reports 4G and 5G network coverage by population and 4G availability metric (percentage of time users can connect to the 4G network). These 4G coverage and 4G availability metrics are almost identical across the three operators. However, Telia has the largest 5G network in terms of population coverage as of June 2021.

Figure 2.28: Network performance – 4G availability (% time accessible) and 4G/5G coverage (% population)



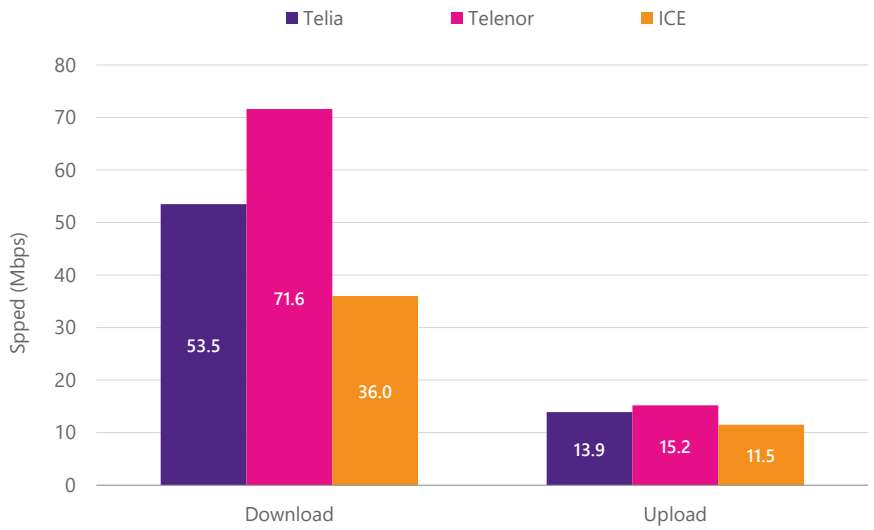
Source: Opensignal (April 2021; 4G availability), GSMA Intelligence (June 2021; 4G population coverage, 5G population coverage)

The following network performance statistics suggest that Telenor has the overall best performing network in terms of network speeds and user experience. Although ICE has lower coverage and network speeds, user experience rated higher than the second largest operator Telia. Figure 2.29 shows average download and

[113] Source: GSMA Intelligence, 2021.

upload speeds as reported by Opensignal in April 2021.[114] Telenor's users experienced the highest download and upload speeds while ICE provided the slowest speeds amongst the three.

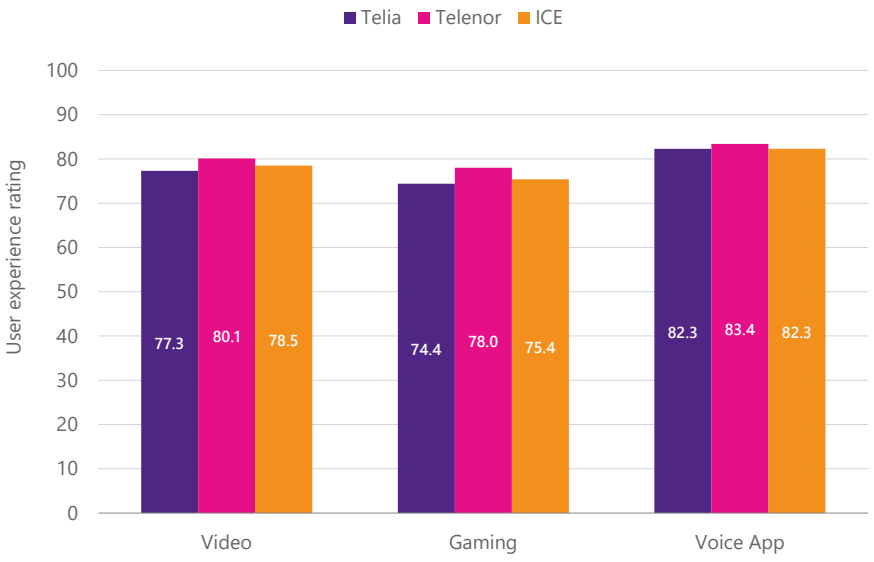
Figure 2.29: Network performance – download and upload speed (2021)



Source: Opensignal (June 2021)

Opensignal's latest report on Norway's mobile network experience was published in June 2021. All the established three MNOs were ranked 'Excellent' in video experience (score of above 75 of 100). An 'Excellent' score in video experience implies a highly consistent experience across all video streaming providers, fast loading times and close to zero stalling – see Appendix B for more details on the scoring criteria. Gaming experience was rated 'Fair' (Telia) and 'Good' (ICE and Telenor) while voice app performance was 'Good' for all three MNOs. These user performance indicators are illustrated in Figure 2.30 below.

Figure 2.30: User experience score, of 100 (2021)



[114] Opensignal, June 2021, Norway – Mobile Network Experience Report June 2021. Available at: https://www.opensignal.com/reports/2021/06/norway/mobile-network-experience

Source: Opensignal (June 2021)

A survey conducted by Deloitte (2019) found that the smartphone penetration in Norway in 2019 was 94% and 54% of the adult population (between 18-75 years) had a mobile plan with a monthly data allowance of 3GB or higher. In terms of the type of applications, 60% of the respondents in the Nordic region (including Norway) used social networking sites through their mobile phone at least once a day, Facebook was the most used application, followed by Instagram, YouTube and TikTok.[115]

2.6.3 Policy and regulatory environment

The *Electronic Communications Act* is the key act for the telecommunications sector regulation in Norway. The Act was originally brought into force in 2003 with various amendments made since. The stated purpose of the Act is to support reasonably priced and future oriented electronic communications services throughout Norway by facilitating sustainable competition and fostering industrial development and innovation. The main provisions include:[116]

- The Act obligates the service provider to measure and notify the quality of the network and service that is offered to the end users.[117] The Act states that Nkom would monitor compliance with requirements laid down in the Act. Nkom is authorised to undertake spot-checks and perform measurements without prior notification.

- Under the Act, Nkom can impose requirements for the installation of specific network equipment, facilities, provision of specific services and the use of standards to ensure interoperability, quality, and efficient utilisation of network capacity.

- The Act also imposes obligations on providers with Significant Market Power (SMP). These can include functional separation, network infrastructure access provided to new entrants, interconnection requirements, and pricing controls for access and interconnection amongst others. SMP operators may also be subject to universal service obligations, and societal obligations such as provision of emergency and safety services (e.g., coastal radio) to meet Norway's international commitments and provision of services in Svalbard (a Norwegian archipelago between the mainland Norway and the North Pole).

- The costs of the universal service obligation can be met through a financing fund where the providers can share these costs. The costs of societal obligations would be borne by the state.

Broadband Development Act (2020)

The *Broadband Development Act* was implemented in July 2020 and its purpose is to contribute towards the cost-effective establishment of high-speed networks for electronic communication in Norway by ensuring access to, and information about, passive physical infrastructure and building and construction work.[118]

[115] Deloitte, 2019, Smartphone: the center of life A study on Nordic mobile consumer behaviour. Available at: https://www2.deloitte.com/content/dam/Deloitte/dk/Documents/technology-media-telecommunications/global-mobile-consumer-survey-2019-nordic-new.pdf

[116] Nkom, 24 June 2020, Act relating to electronic communications (The Electronic Communications Act). Available at: https://lovdata.no/dokument/NLE/lov/2003-07-04-83

[117] These can include prices to end-users, geographic unit prices, quality requirements for the services, measurement of quality and information. For example, as part of the 700 MHz auction, the Nkom specified a series of coverage obligations pertaining to minimum download speeds (5 Mbps), deployment conditions for transport routes and investment requirements pertaining to number of base stations and coverage improvements achieved.

[118] Nkom, July 2020, Act on facilitation for the development of high-speed networks for electronic communication (Broadband Development Act). Available at: https://lovdata.no/dokument/NL/lov/2020-05-07-40

The infrastructure within the scope of the Act includes electronic communications networks, electricity networks, water and sewage networks, infrastructure for heating and transport services, including railway and road networks, ports and airports. The following are key provisions of the Act:[119]

- to develop central information service — a web portal with information on the owners of the physical infrastructure suitable for the transmission of high-speed networks and information on planned or ongoing construction work in relation to the development of high-speed networks. Nkom notes that this service should have been available in the first half of 2021.
- network operators[120] are obligated to provide access to and information on passive physical infrastructure when requested (access can be denied on the grounds of technical suitability, space constraints, network security and integrity).
- the type of information that the network operator is expected to provide to the broadband developer should at least include location, route and infrastructure type.

2.6.3.1 Measures to address market power and promote competition

Under the *Electronic Communications Act,* Nkom has designated Telenor as an entity with significant market power on three occasions – in January 2006, August 2010 and July 2016. The most recent obligations that have been imposed on Telenor are highlighted below.[121]

SMP obligations imposed on Telenor

- **Access:** obligation to provide general access i.e., to meet any reasonable request for call origination and access to its network. To provide access for mobile, national roaming, co-location, and virtual network operators (MVNOs).
- **Non-discrimination:** to not discriminate on any terms of access (including price) while providing access or for the purpose of co-location.
- **Publishing and reference offers:** to draw up reference offers for providing access and co-location and to publish these on its website. This could include financial information, technical specifications, network characteristics and prices.
- **Price and accounting controls:** to provide access and national roaming at prices which do not cause a margin squeeze of the access seeker. Nkom would conduct margin squeeze tests to determine if Telenor's prices are resulting in a positive or negative margin for the access seekers. From February 2017, Nkom conducted several margin squeeze tests on some of Telenor's products and many of these tests were not passed. In response, Nkom ordered Telenor to reduce its access prices and Telenor had to take corrective action.

Remedies imposed on Telia

[119] Nkom, March 2021, Facilitate the development of broadband. Available at: https://www.nkom.no/fysiske-nett-og-infrastruktur/informasjonsportal-for-utbygging-av-bredb%C3%A5nd

[120] Network Operator under this act include electronic communications network businesses and or those entities that have the right to dispose of passive physical infrastructure intended to deliver. These would include – electricity network owners, municipalities etc.

[121] Nkom, 14 May 2020, Decision on designating undertakings with significant market power and imposing specific obligations in the market for access and call origination on public mobile telephone network. Available at: https://www.eftasurv.int/cms/sites/default/files/documents/gopro/200514%20M15%20Decision%20Public_.docx.pdf

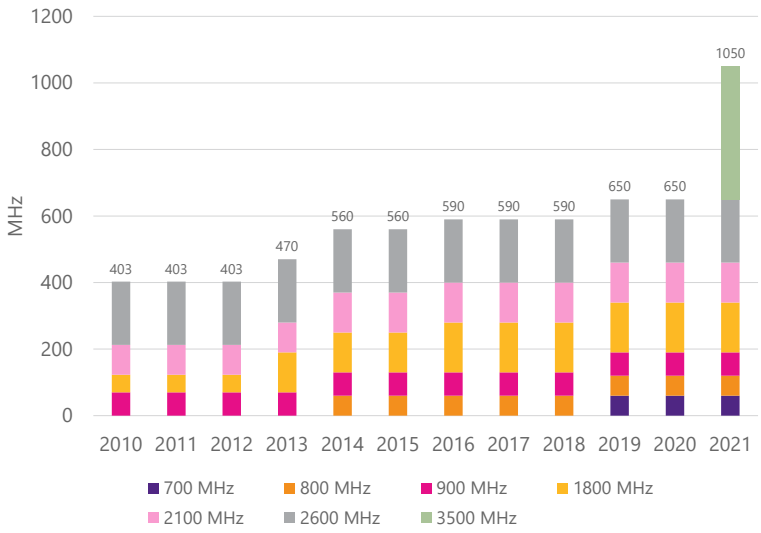
Separately, the acquisition of Tele2 by Telia in 2014 led to a series of undertakings by Telia following an investigation by the Norwegian Competition Authority.[122] Tele2, the third operator in Norway at the time, had failed to win any spectrum at the 4G auction in 2013, losing out to a new entrant ICE.

The remedies, which were both structural and behavioural, were designed to increase the competitiveness of the new entrant ICE. The most significant remedies included (a) transfer of Tele2's mobile network to ICE; (b) transfer of the customer portfolio of Network Norway[123] to ICE (approximately two-thirds of Tele2's business portfolio), (c) commitment to offer national 2G, 3G and 4G roaming access to ICE for a period of six years, and (d) network co-location offered to ICE (to reduce the costs of ICE's network investments). These measures helped to enable ICE to become a more credible competitor to Telenor and Telia.

2.6.3.2 Spectrum policy and management

The total amount of spectrum assigned to the mobile operators in Norway is 1050 MHz in the frequencies below 6 GHz as shown in Figure 2.31. This follows the recently concluded auction of the 2.6 GHz and 3.5 GHz bands.

Figure 2.31: Sub-6 GHz spectrum assigned for mobile services in Norway



Source: ECO, national regulator, Plum analysis

The most recent auction involving the 2.6 GHz and 3.5 GHz bands was concluded in September 2021. As part of the auction design, operators were given an option to take a development obligation, i.e., provision of fast broadband per building. This obligation is being imposed as the Government intends to use the auction proceeds (expected NOK 560 million) for the development of fast wireless broadband in certain rural districts. The auction winners who take up the development obligation would receive a discount from the auction price for each household and commercial building in rural areas that can receive a 100 Mbps broadband service,[124]

[122] Norwegian Competition Authority, 21 October 2015, The Norwegian Competition Authority clears the acquisition of Tele2 by TeliaSonera, subject to conditions. Available at: https://konkurransetilsynet.no/the-norwegian-competition-authority-clears-the-acquisition-of-tele2-by-teliasonera-subject-to-conditions/?lang=en

[123] Network Norway was a primarily a business market operator which Tele2 had acquired in 2011.

[124] Nkom specified 100 Mbps download, 10 Mbps upload.

either based on the MNO's existing sites or through new sites. The list of buildings in rural areas that were deemed to be not feasible for commercially profitable provision was published by Nkom ahead of the auction.[125]

Along with the three incumbent MNOs, Altibox, a provider of fibre broadband and TV services, also secured spectrum at this auction.[126] Of the four winners, Altibox, Telia and Telenor chose to accept the commitment and received a total discount of NOK 480 million (£41.3 million).

In 2019, Nkom assigned the 700 MHz and 2100 MHz bands.[127] Coverage obligations were attached to two blocks of the 700 MHz band, related to providing coverage for designated transport routes including railway and highways.[128]

In 2020 Nkom also auctioned a number of high-band frequencies in 10 GHz, 13 GHz, 18 GHz, 23 GHz, 28 GHz, 32 GHz and 38 GHz bands for fixed links.[129] The 26 GHz band which has been identified as a pioneer 5G band in Europe is planned to be assigned for regional or local private networks in 2022. Nkom also recently announced the opening up of the 3.8-4.2 GHz band for local 5G networks based on two types of licences – low power licence for local private mobile networks for indoor coverage and high-power licence for provision of fixed wireless broadband and industrial parks.[130]

2.6.3.3 Coverage and quality monitoring

Nkom tracks the coverage of mobile and fixed broadband networks and publishes maps on the availability of broadband services by speed (10 Mbps, 30 Mbps, 100 Mbps) and technology (mobile, HFC, xDSL, FTTx, FWA). The information is published annually and can be used by businesses and individuals to assess the status of broadband in their areas, and for county municipalities to apply for public grants as part of the Broadband Support Scheme. [131]

The objective of the scheme is to support the development of broadband in areas where it might not be commercially viable for the operators to do so. The operators that receive funding would be required to offer passive and wholesale access on non-discriminatory terms. The type of access would depend on the type of technology of the provider. For mobile and fixed wireless networks, this includes access to masts, bitstream access, and backhaul networks.

The funds are allocated from the state budget. For the year 2021, a total of NOK 364 million (approximately £30 million) has been assigned under this scheme.

2.6.3.4 2G and 3G switch-off

[125] More information is available at https://www.nkom.no/frekvenser-og-elektronisk-utstyr/frekvensauksjoner/auksjon-av-2-6-ghz-og-3-6-ghz-bandene

[126] Nkom, 30 September 2021, The Norwegian 5G auction has concluded. Available at: https://www.nkom.no/aktuelt/the-norwegian-5g-auction-has-concluded

[127] Telegeography,6 June 2019, Nkom announces results of 700MHz, 2100MHz spectrum auction. Available at: https://www.commsupdate.com/articles/2019/06/06/nkom-announces-results-of-700mhz-2100mhz-spectrum-auction/

[128] Nkom, 20 December 2018, "Auction of the 700 MHz and 2.1 GHz bands - consultation of auction rules." Available (in Norwegian) at: https://www.nkom.no/hoeringer/auksjon-av-700-mhz-og-2-1-ghz-bandene-horing-av-auksjonsregler

[129] Nkom, March 2020, "The radio line auction: Final Auction Rules." Available (in Norwegian) at: https://www.nkom.no/frekvenser-og-elektronisk-utstyr/frekvensauksjoner/radiolinjeauksjonen

[130] Nkom, 9 June 2021, "Final terms for the 5G auction starting September 27; Offers new frequency band for local 5G networks." Available (in Norwegian) at: https://www.nkom.no/aktuelt/endelige-vilkar-for-5g-auksjonen-som-starter-27.september

[131] Nkom, 11 January 2021, "Public support for broadband development." Available (in Norwegian) at: https://www.nkom.no/fysiske-nett-og-infrastruktur/offentlig-stotte-til-bredbandsutbygging

As of January 2021, all 3G services have been switched off in Norway.[132] Telenor and Telia had begun the process of phasing out the 3G networks since 2019.[133] Telenor had earlier announced plans to shut down its 2G networks five years after the shut-down of the 3G services. The reason for the slower phase out of 2G is the need for continued support of M2M communications.[134]

2.6.4 Service pricing

Mobile prices in Norway are slightly higher than EU average but substantially lower than the US. The differential between the low and high use baskets is also higher than the EU average but lower than the US as shown in Figure 2.32.

Figure 2.32: Comparison of selected mobile baskets in Norway, 2019 (EUR PPP)

Basket (individual handheld)	Norway	EU27	US
0.5 GB mobile data, 30 calls	11.93	10.38	36.50
2 GB mobile data, 100 calls	17.57	15.87	46.50
20 GB mobile data with 100 calls	37.33	31.51	67.79

Note: Based on least expensive offers in each market.
Source: European Commission

Mobile offers from the three MNOs vary by data allowance (typically around five to seven tariff options offering from 1 GB to unlimited data per month) and tend to include data rollover and unlimited voice, SMS and MMS. ICE offers the lowest cost packages and Telenor is the highest cost carrier.[135] The operators offer discounts for multiple (family) subscriptions and both Telenor and Telia have additional offerings for young people (18-28 years) that offer discounted services or additional subscriptions, such as music or video streaming.

Telenor is the only MNO that allows subscribers to choose connection speed. Telenor's unlimited data package allows users to select between three maximum speeds; normal (10 Mbps) for 549 NOK/month, fast (100 Mbps) for 599 NOK/month and maximum (up to 300 Mbps on 4G and up to 1000 Mbps on 5G) for 799 NOK/month.[136] Network speed for other Telenor packages (different data allowances) is generally specified as maximum speed available.

Telia and ICE subscribers are not able to select speeds as part of their mobile baskets. Telia's unlimited data packages advertise unlimited speeds up to 100 GB data usage, after which the data rate is restricted to 3 Mbps. On the other hand, ICE does not offer an unlimited data allowance; the largest data allowance is 30GB per month. Bandwidth throttling tends to apply once the data allowance has been consumed, and the restrictions are advertised as part of the tariff terms.

[132] Cullen International, 6 July 2021, New benchmark on switching off 2G and 3G networks in Europe. Available at: https://www.cullen-international.com/news/2021/07/New-benchmark-on-switching-off-2G-and-3G-networks-in-Europe.html
[133] Telia Company, 3 September 2018, 2G and 3G networks to retire. Available at: https://www.teliacompany.com/en/news/news-articles/2g-and-3g-networks-to-retire--norway-first-out/
[134] Telegeography, 3 June 2015, Telenor Norway closing down 3G network in 2020; 2G switch-off to happen five years later. Available at: https://www.commsupdate.com/articles/2015/06/03/telenor-norway-closing-down-3g-network-in-2020-2g-switch-off-to-happen-five-years-later/
[135] Based on Plum survey of Norwegian mobile retail offers.
[136] Based on Plum survey of Telenor offers, reviewed on 08/09/2021.

According to Nkom, the most common mobile phone plans include a data quota of 1GB or more but less than 5GB – these comprise 41% of the total subscriptions at the end of 2020. Further, 21% of subscriptions had monthly data allowances of 10 GB or more.[137]

2.6.5 Appraisal

High quality networks in Norway are driven by a combination of market and policy factors but regulatory intervention appears to have the largest influence.

SMP regulations on Telenor and regulatory undertakings by Telia, as a result of the Tele2 acquisition, have helped to support the development of ICE as a credible third MNO in the Norwegian market. These have included the transfer of network assets to ICE, a national roaming agreement and network co-location to reduce cost of network investment. As a result ICE has been able to compete with Telenor and Telia on price and quality and grow its market share. Furthermore MVNO access requirements imposed on Telenor mean that the majority of MVNOs are hosted on Telenor's network.

There are also obligations related to measuring and notifying Nkom of network quality. This information is used by Nkom to support its broadband development programme and help in designing measures to target specific areas or locations that do not have access to high quality networks. For example, the recent auction of 2.6 GHz and 3.5 GHz bands included discounts for operators taking up obligations to improve coverage and service quality in rural areas.

The 3G shutdown is led by the operators. While this will help increase efficiency of spectrum use, it is too early to assess the exact impact on network quality.

[137] NKOM, May 2021, "The e-commerce market all year 2020." Available (in Norwegian) at: https://ekomstatistikken.nkom.no/#/article/ekom2020#mobil

2.7 Taiwan

Motivation for selection: Competitive market with five MNOs and resulting spectrum constraints, leading to active spectrum management by regulator and MNOs.

Key market & supply chain features	
Mobile network operators (market share, if available)	APT (5-10%), Chunghwa Telecom (33-38%), FarEasTone (22-27%), Taiwan Mobile (23-28%), Taiwan Star (5-10%) (2021 Q2)
Mobile virtual network operators	Total MVNO market share <1%. Main MVNOs and resellers include 7-Circles.Life (Liberty Wireless), LINE Mobile, Telkom Taiwan (Telkom Indonesia), Smart Pinoy (FarEasTone), Carrefour Telecom, ibon mobile, IDEAL CARD (Chunghwa Telecom)
Other notable players in broadband supply chain	All MNOs, apart from Taiwan Star have fixed networks. CHT and Taiwan Fixed Network (TWM) are the two main fixed players. Several smaller regional cable operators.
LTE coverage (% population)	99.3% (2021 Q2)
5G coverage (% population)	73.0% (2021 Q2)
Data speeds (average download & upload) – LTE	44.2 Mbps download, 11.1 Mbps upload (2021 Q2)
Network availability – LTE	92.8% to 96.8% - varies by operator (2021 Q2)
Sub-6 GHz assigned for MNOs	860 MHz
Sub-1 GHz assigned for MNOs	150 MHz
Total cells, excluding 5G (thousands)	470.7
Total cells / 000' pop	19.8
Total cells/ sq.km	13.29
Population (million)	23.8 (2021 forecast)
Rural population (%)	21% (2020)
Land Area (sq.km)	35,410 (2021)
GDP per capita (US$, current)	32,219 (2021 forecast)
Mobile broadband penetration (%)	115.9 (2020)
Mobile data usage (GB/month/sub)	22.4 GB (2020)

Source: Plum, GSMA Intelligence (2021 Q2), analysis by Opensignal (2021 Q2 values), World Population Review (2020 values), National Communications Commission of Taiwan (NCC) (2020), National Statistics Republic of China (Taiwan) (2021 forecast), OpenCellid (October 2021), ITU.

2.7.1 Market overview and key players

The Taiwanese mobile market is highly competitive, characterised with fierce price competition which has resulted in a persistent decline in mobile revenues.[138] There are five major mobile network operators, comprising three large operators – Chunghwa Telecom (CHT), FarEasTone (FET) and Taiwan Mobile (TWM) – who make up around 85% of the market, and two small operators, Asia Pacific Telecom (APT) and Taiwan Star (T-Star).

[138] Retail price competition between MNOs has resulted in declining industry revenues. This has intensified since 2016, with average monthly ARPU per connection declining by 25% from US$23.73 to US$17.53 in 2021 (annual averages as reported by GSMA Intelligence in 2021 Q3). ARPU per connection over this period has declined for each MNO.

- Chunghwa Telecom is the incumbent fixed line operator and the largest mobile network operator in Taiwan in terms of market share. As a fully integrated operator, it offers retail fixed line communications and broadband access, IPTV and mobile communications services. It is also the main provider of leased lines in Taiwan and offers a range of enterprise and international carrier services.

- Taiwan Mobile is a major player in the mobile market and is second behind CHT in terms of market share by connections as of Q2 2021. TWM also provides retail fixed broadband and cable TV services for consumers, and enterprise services for business customers. It also operates an e-commerce and TV shopping platform through its subsidiary momo.

- Far EasTone is the third of the three large mobile network operators (along with CHT and TWM). Its market share by connections is similar to TWM. It is also a provider of services to enterprise customers such as cloud and IoT solutions.

- Asia Pacific Telecom is one of the two small mobile operators with less than 10% market share as of Q2 2021. APT launched its LTE network in 2014. Previously it had operated a CDMA network in the 850 MHz band. In addition to its mobile business, APT also provides fixed data communication services and Internet of Things (IoT) solutions for enterprise customers. APT merged with Ambit (Hon Hai) in 2015.

- Taiwan-Star (T-Star) is the other small mobile operator. After acquiring spectrum at the 2013 4G auction, it merged with Vibo, a 3G operator, and entered the market in 2014. Among the five MNOs, T-Star is the only pure play mobile operator and has less than 10% market share.

The MNOs' subscriber market shares have been fairly constant between 2015 to 2020. However there has been aggressive price competition between the MNOs triggered by the introduction of low-cost unlimited data plans, which has seen ARPU falling by more than 50% over the same period.[139] The introduction of 5G in 2020 has not significantly altered the market dynamics, although APT's lack of 3.5 GHz spectrum could be a reason for its lower 5G market share. It has since entered into a spectrum sharing arrangement with FET (see Section 2.5.3.2).

Figure 2.33: Market shares by subscribers (2015 vs 2021)

Operator	Market share in Q2 2015	Market share in Q2 2021
Chunghwa Telecom	35 – 40%	32 – 37%
FarEasTone	23 – 28%	22 – 27%
Taiwan Mobile	23 – 28%	23 – 28%
Taiwan Star	~5%	5 – 10%
Asia Pacific Telecom	~5%	5 – 10%

Source: GSMA Intelligence

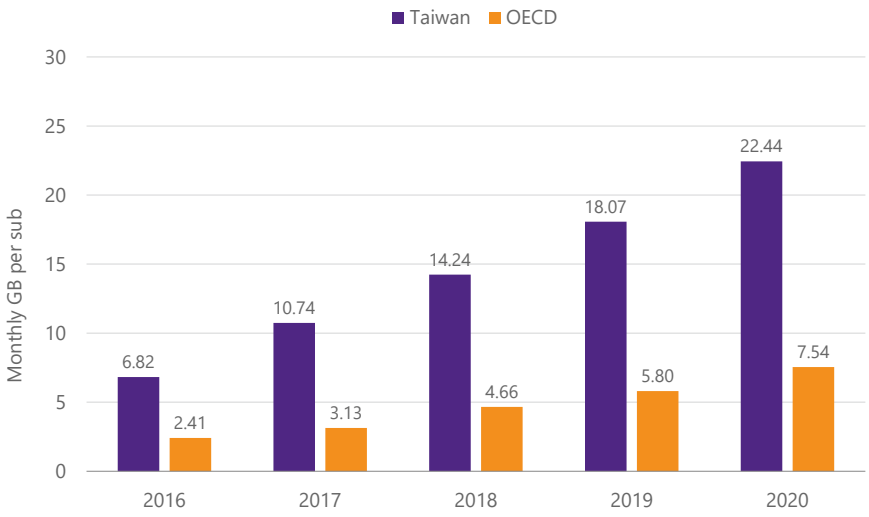
In addition to these key players, GSMA Intelligence reports seven live MVNOs in Taiwan operating over the MNOs' networks (three hosted by CHT, three by FET, and one by T-Star). As of 2020, these MVNOs serve approximately 117,000 customers or 0.4% market share. The majority of MVNOs offer prepaid subscriptions targeting low-cost (discount) segment though Telkom Taiwan (Telkom Indonesia) and Smart Puinoy (FET) offer international packages targeted at migrant workers. ibon mobile and Carrefour Telecom were early entrants, launching services in 2008, and the most recent entrant is Circles.Life that launched in June 2019.

[139] Source: Plum analysis and GSMA Intelligence, 2021.

2.7.2 Network performance and usage

Mobile data usage in Taiwan is among one of the highest globally. As of 2020, the monthly average per subscription is 22.4 GB, around three times that of the OECD average as shown in Figure 2.27. Since 2014 when LTE was launched, total annual data traffic has grown by 10-fold, reaching 7,513.64 PB in 2020.[140]

Figure 2.34: Mobile data usage trends – Taiwan vs OECD



Source: NCC, OECD

The trend in growing data usage has been driven by the availability of unlimited mobile data plans and consumer preference for such offers. The annual market survey by the Taiwan regulator NCC revealed that 81.7% of adults (16 years and above) have unlimited mobile plans, up from 67.1% in 2017.[141] As a result, there also appears to be a degree of fixed-mobile substitution among broadband households – the proportion of households with a fixed broadband connection fell from 75.9% in 2017 to 65.8% in 2020. The majority of survey respondents (66.3%) indicated that mobile broadband was the most common way of accessing online services in their homes, up from 50% in 2017. The use of Wi-Fi through a fixed connection has declined over the same period.

Among adult Internet users in Taiwan, mobile chat and social networking apps rank as the most popular with over 95% usage. There is also high adoption of more data-intensive applications such as entertainment and video (82.4%) and gaming (59.3%) which explains the high average mobile data usage in Taiwan.

Figure 2.35: Monthly app use among internet users (16-64 years) in Taiwan (2020)

Type of mobile app	Percentage of internet users 16-64 years
Chat (messengers)	96.2%
Social networking	95.2%
Entertainment and video	82.4%
Music	55.6%

[140] Source: NCC, 2021
[141] NCC, 2020, Communications Market Survey. Available (in Chinese) at https://www.ncc.gov.tw/chinese/files/21021/3734_45723_210217_1.pdf

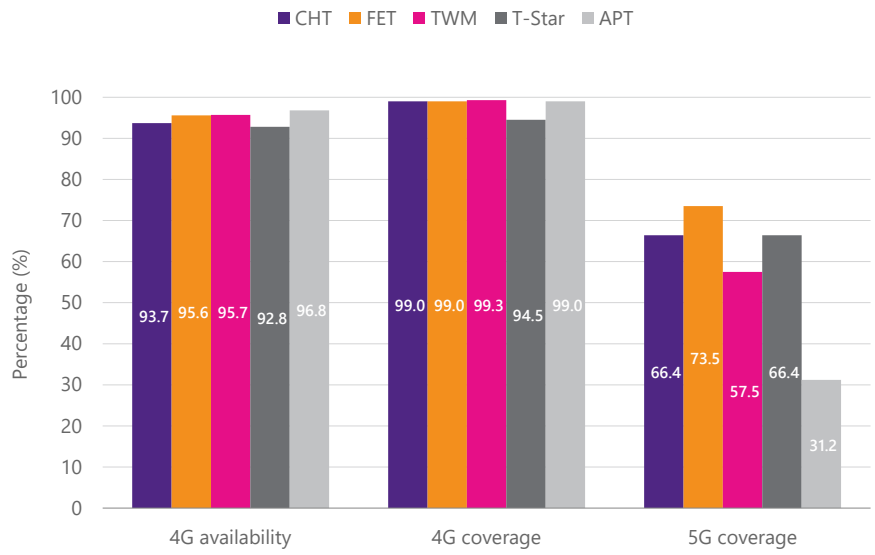
Type of mobile app	Percentage of internet users 16-64 years
Games	59.3%
Shopping	58.3%
Map	86.4%
Banking and financial services	49.2%
Health, fitness and nutrition	24.9%
Dating and friendship	8.6%

Source: GlobalWebIndex

As of 2021 the coverage of 4G in Taiwan is 99.3% of the population although there is more variation in coverage levels across the five MNOs.[142] As shown in Figure 2.36 the three big MNOs – CHT, TWM, FET – have 99% or better 4G coverage while T-Star's 4G network coverage is lower at 94.5%.

All five of Taiwan's mobile networks score highly in terms of 4G availability (defined as the percentage of time user can connect to 4G network). Additionally, 5G coverage in Taiwan has reached 73.5% in June 2021, with FET having the largest 5G network in terms of population coverage.

Figure 2.36: Network performance – 4G availability (% time accessible) and 4G/5G coverage (% population)



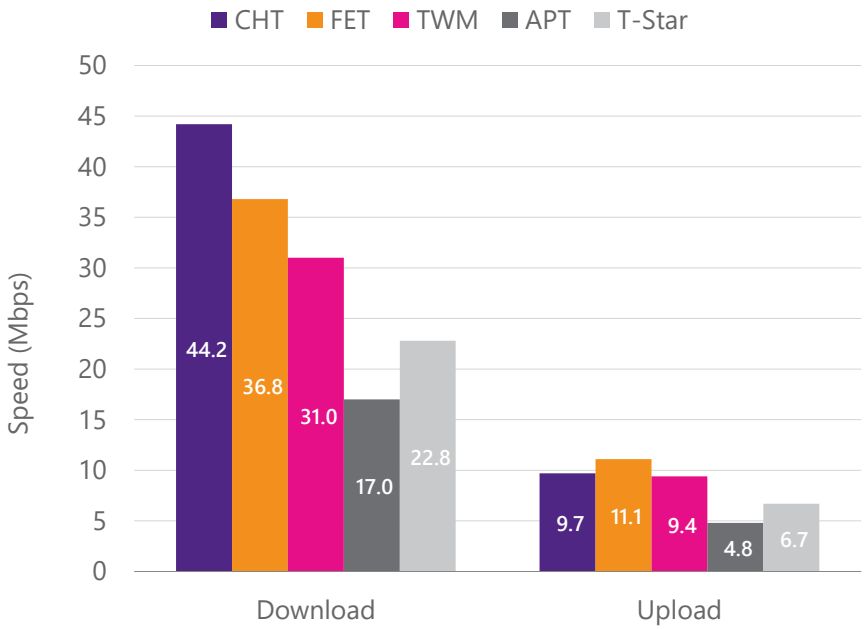
Source: Opensignal (June 2021; 4G availability, 5G availability), GSMA Intelligence (June 2021; 4G population coverage, 5G population coverage)
Note: Data on 5G availability for APT is not available.

Figure 2.37 shows the average overall download and upload speeds as reported by Opensignal[143] in June 2021. The highest download speed has been experienced by CHT's users and the highest upload speed by FET's users.

[142] Source: GSMA Intelligence, 2021.
[143] Opensignal, June 2021, Taiwan – Mobile Network Experience Report. Available at: https://www.Opensignal.com/reports/2021/06/taiwan/mobile-network-experience

On a global basis, Taiwan is ranked second on the 5G download speed (309.9 Mbps) right after South Korea (361.0 Mbps) and tops the international ranking for 5G upload speed (36.7 Mbps).[144]

Figure 2.37: Network performance – overall download and upload speed (2021)

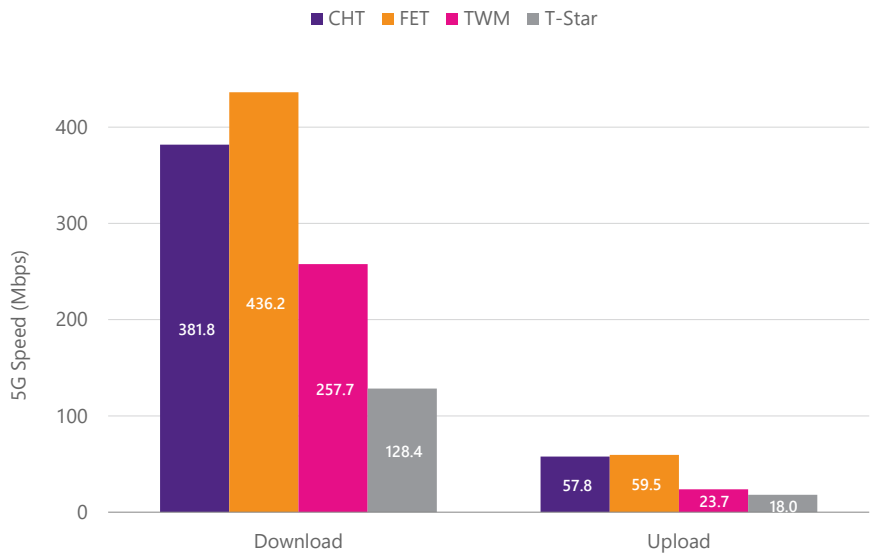


Source: Opensignal (June 2021)

Figure 2.38 shows the average overall download and upload speeds for 5G services as reported by Opensignal in June 2021.[145] Notably, FET which has the largest 5G population coverage also reports the highest 5G download and upload speeds (436.2 Mbps and 59.5 Mbps respectively). T-Star performs poorly compared to its competitors in 5G availability and speed (128.4 Mbps download and 18.0 Mbps upload). T-Star was the last MNO to announce the commercial launch of 5G services.

[144] Opensignal, 15 April 2021, Benchmarking the Global 5G Experience – April 2021. Available at: https://www.Opensignal.com/2021/04/15/benchmarking-the-global-5g-experience-april-2021
[145] Opensignal, June 2021, Taiwan – 5G User Experience Report June 2021. Available at: https://www.Opensignal.com/reports/2021/06/taiwan/mobile-network-experience-5g

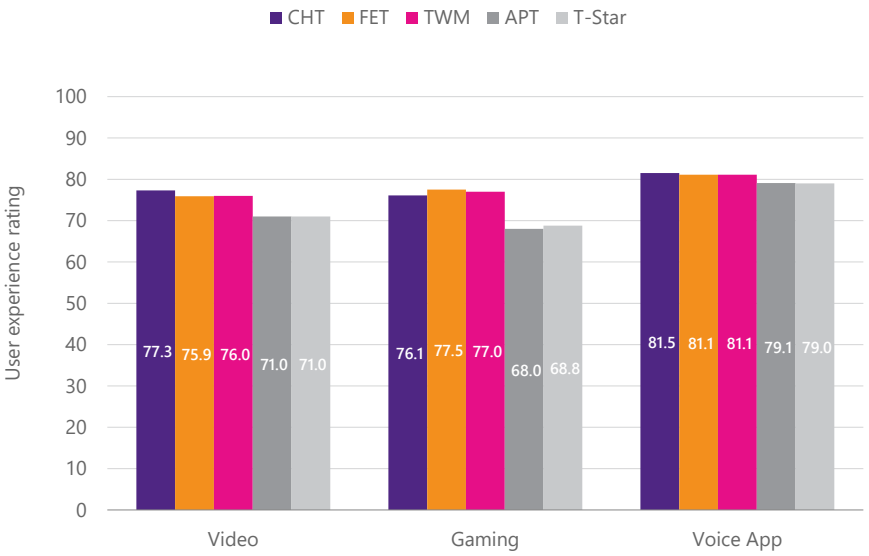
Figure 2.38: 5G Network performance – download and upload speed (2021)



Source: Opensignal (June 2021)

Figure 2.39 reports Opensignal's metrics for video experience, gaming experience and (OTT) voice app experience – see Appendix B for more details on the scoring criteria. CHT seems to be the best provider of video and voice app experiences although it ranks behind FET and TWM for gaming experience. The user experience rankings for the two smaller MNOs are lower than those for the three main players.

Figure 2.39: User experience score, of 100 (2021)



Source: Opensignal (June 2021)

2.7.3 Policy and regulatory environment

The main legislation governing the telecommunications sector in Taiwan is the *Telecommunications Management Act*[146] (TMA) which came into force in July 2020. The TMA is replacing the previous *Telecommunications Act*[147] (TA) over a three-year transition period from July 2020 to June 2023.

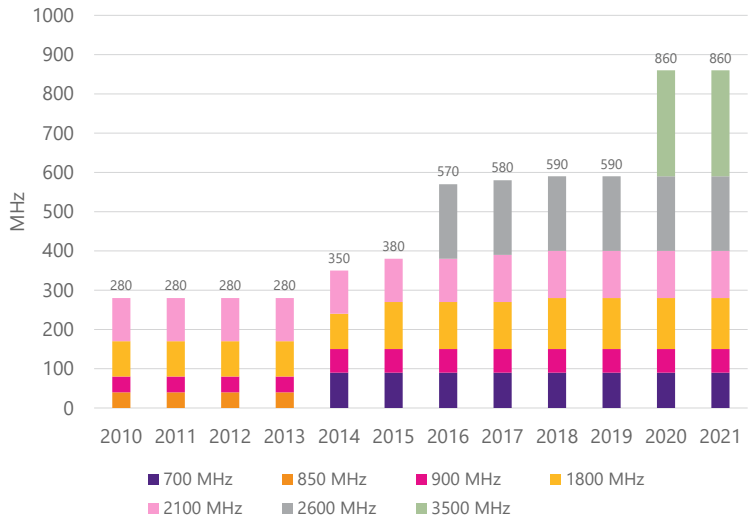
The TMA's objective is to ensure the sound development of the telecommunications industry, to encourage innovative services, to facilitate fair market competition and telecommunications infrastructure, to ensure the reasonable use and efficiency of resources, to improve technological development and interconnection applications, and to protect the rights and interests of consumers. The competent authority to enforce this act is the National Communications Commission (NCC).

The regulatory framework of mobile telecommunications also include *Regulations for administration of mobile broadband businesses*,[148] which imposes service quality obligations (including those associated with services provided to MVNOs) and coverage obligations on the MNOs, *Regulations for Wireless Broadband Access*, *Regulations for administration of base stations of mobile communications network businesses*, and *Regulations for administration of base stations of public telecommunications network*. These regulations do not include any specific details on deployment though technology deployment is a condition of the operators' spectrum licence.[149]

2.7.3.1 Spectrum policy and management

There is currently 860 MHz of spectrum below 6 GHz that has been assigned to mobile operators in Taiwan as shown in Figure 2.40. Another 1600 MHz in the 28 GHz band has been assigned.

Figure 2.40: Sub-6 GHz spectrum assigned for mobile services in Taiwan



Source: National regulator, Plum analysis

[146] Ministry of Justice, 26 June 2019, Telecommunications Management Act. Available at: https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=K0060111
[147] Ministry of Justice, 11 December 2013, Telecommunications Act. Available at: https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=K0060001
[148] NCC, 11 July 2017, Regulations for Administration of Mobile Broadband Businesses. Available at: https://www.ncc.gov.tw/english/news_detail.aspx?site_content_sn=66&is_history=0&pages=0&sn_f=2088
[149] Taiwan Institute of Economic Research, December 2020, "Micro Base Station Deployment and Regulation Adjustment in the 5G Era."

Over the last 10 years the Taiwanese market has been characterised by a high level of competition with at least five operators at any point in time. While Taiwan was a relative latecomer to 4G in late 2013, the 2013 auction, which involved the 700 MHz, 900 MHz and 1800 MHz bands, saw several new entities acquire spectrum, including Taiwan-Star and Ambit.[150] The aftermath was a prolonged period of intensive competition and price war among the operators.[151] Total mobile revenue and ARPU in Taiwan has fallen by 17% and 25% respectively from 2016 to 2020, prompting the NCC to voice concerns in 2018 over industry sustainability and investments in 5G.[152] Since the 2013 auction, there have been auctions in 2015 for the 2600 MHz band and in 2017 for the reassignment of the 2100 MHz band.[153]

In early 2020 the NCC completed the auction of 5G spectrum in the 3.5 GHz and 28 GHz bands. The auction offered a total of 2790 MHz of spectrum across three bands – 20 MHz from 1800 MHz band (left over from the 2017 auction), 270 MHz from the 3.5 GHz band and 2500 MHz from the 28 GHz band. There was fierce competition for the 3.5 GHz band, which saw the auction stretch to 261 rounds, reflecting its importance in the operators' strategies for 5G.[154] The 270 MHz of the 3.5 GHz band was split between CHT (90 MHz), FET (80 MHz), TWM (60 MHz) and T-Star (40 MHz). APT failed to acquire any of the 3.5 GHz band. In contrast, the 28 GHz saw relatively limited activity with 900 MHz (of the 2500 MHz available) left unsold.

To ensure rapid rollout of 5G in Taiwan, the NCC imposed the following coverage and rollout obligations:

- For the 3.5 GHz band, winning licensees are required to:
  - Reach 50% population coverage for their 5G networks within five years; this can be achieved using the 3.5 GHz band or by refarming existing 4G bands; and
  - Deploy at least 1,000 5G base stations using the 3.5 GHz band.
- For the 28 GHz band, winning licensees are required to deploy at least 375 5G base stations for every 100 MHz acquired, up to 3,000 5G base stations.

2.7.3.2 Network and spectrum sharing

One of the key changes under the TMA is the introduction of more flexibility for network and spectrum sharing among operators.[155] These new provisions are intended to help reduce the costs of 5G deployment and encourage more rapid rollout of 5G networks. Previously, under the TA, spectrum sharing was not permitted and operators seeking to enter into active network sharing had to seek specific approval from the NCC.[156]

The *Regulations for Administration of Mobile Broadband Businesses*[157] set out the framework for network and spectrum sharing. Mobile network operators are required to deploy their own 4G and 5G core networks

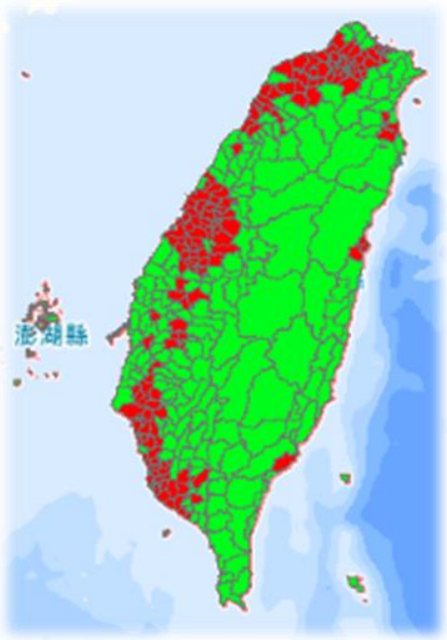
[150] A subsidiary of Hon Hai (Foxconn) which later merged with APT.
[151] Taipei Times, 10 May 2018, New NT$499 data plan fuels price war. Available at: https://www.taipeitimes.com/News/biz/archives/2018/05/10/2003692803
[152] Taipei Times, 23 April 2018, Price war could hamper development of 5G: NCC. Available at https://www.taipeitimes.com/News/taiwan/archives/2018/04/23/2003691847
[153] The spectrum management framework in Taiwan requires expiring spectrum to be reassigned via auction.
[154] The 270 MHz of 3.5 GHz band in Taiwan was sold for a total of NT$140.5 billion (£3.7 billion). In contrast, the 390 MHz of the 3.5 GHz in Finland was sold for a total of €77.6 million (£65.8 million).
[155] Prior to this, network sharing was only permitted at the core network level. Other forms of sharing arrangements would have to be approved by the NCC subject to meeting specific criteria on network deployment.
[156] In 2019 APT and TWM were granted permission by NCC to enter into a 4G rural roaming agreement which allowed APT to extend its 4G coverage. Source: Taipei Times, 19 June 2019, Taiwan Mobile APT gain approval to forge rural roaming partnership. Available at: https://www.taipeitimes.com/News/taiwan/archives/2019/07/19/2003718946
[157] Ministry of Justice, 3 September 2019, Regulations for Administration of Mobile Broadband Businesses. Available at: https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=K0060091

individually.[158] At the radio access network (RAN) level, sharing among operators is permitted on a geographic basis for:

- Areas where the population density is below average (low density) – all forms of sharing (passive and active components) are allowed; and
- Areas where the population density is above average (high density) – only passive sharing is allowed.

Figure 2.41 shows the categorisation of the high-density (red) and low-density (green) areas in Taiwan.

Figure 2.41: High-density (red) and low-density (green) areas[159]



Source: NCC

For spectrum sharing there is no geographic restriction. For both network and spectrum sharing arrangements, operators are required to submit the details of their cooperation agreement, operating plan and network establishment plan to NCC for prior approval before implementation. Operators are also required to specify measures that will be taken to ensure protection of consumers in the event that the sharing arrangements are terminated.

In September 2020, FET and APT announced a proposed sharing arrangement[160] involving:

- **Spectrum pooling in 3.5 GHz band** – APT will pay FET NT$9.5 billion[161] for access to FET's 3.5 GHz capacity (3340-3420 MHz) for a period of 20 years.

[158] The core network components and functions for 4G and 5G are specified in the new Act. For 4G, these include Mobility Management Entity (MME), Home Subscriber Server (HSS), Policy and Charging Rules Function (PCRF), Serving Gateway (SGW), Packet Data Network Gateway (PGW). For 5G, these include Access Management Function (AMF), Session Management Function (SMF), Authentication Server Function (AUSF), Unified Data Management (UDM), Policy Control function (PCF), User plane Function (UPF), Network Slice Selection Function (NSSF), Network Exposure Function (NEF) and Network Function Repository Function (NRF).

[159] Note: Areas with population density per sq.km above 652 are in red and below 652 in green. Source: NCC briefing slides, 18 July 2019.

[160] APT/GT, 7 September 2020, "Asia Pacific Telecom and FarEast share frequency and network." Available (in Chinese) at: https://aptg.com.tw/corporate/news-center/press-releases/PressRelease-000823/

[161] The amount is equivalent of two-ninths of FET's winning price for the 3.5 GHz spectrum in the auction which concluded in February 2020.

- **Co-operation on 5G network and frequency matters** – FET and APT are looking to improve network and resource efficiency through network and frequency sharing in the long term.

- **FET acquisition of minority stake in APT through a share swap** – A share swap deal involving FET paying NT$5 billion to acquire an 11.58% stake in APT.[162] This will be increased to 23.8% by June 2022. The deal would give FET two seats on APT's board of directors.

The arrangement has been approved by the NCC and the Fair Trade Commission. The regulator imposed two conditions, which required the two firms to commit to building 2,000 more base stations to expand their 5G coverage and to set up a task force to ensure that both have the ability to control the 5G network and monitor information security issues. The two parties are also prohibited from sharing information relating to other operational matters such as setting of tariffs, handset subsidies and marketing activities, and records of relevant shareholder and board meetings have to be submitted to the FTC.[163]

2.7.3.3 2G and 3G switch off

Taiwan is among the earliest markets to have phased out both 2G and 3G. The 2G licences expired in June 2017, although operators continued to offer 2G services over their respective 4G infrastructure until August 2017. Following the expiry of the 2100 MHz licences in 2018, 3G was also phased out and 4G is the main mobile technology in use today. The back-to-back moves to phase out 2G and 3G was due to the need to address growing mobile data usage and the relatively limited supply of spectrum in Taiwan which was divided among five MNOs. The NCC was involved in publicity campaigns to increase consumer awareness of the switch-off and to encourage 3G subscribers to switch over to 4G service plans.

The phase out of 2G and 3G networks has allowed operators to address growth in mobile data consumption by refarming their spectrum holdings to 4G. All five operators have launched VoLTE although there is still some provision for 3G (UMTS) services for voice and in-bound roaming. It has been reported that NCC would permit the full shutdown of 3G by 2024 if consumers are protected and adoption of VoLTE is sufficiently high.[164]

2.7.3.4 Speed and quality monitoring

The NCC has commissioned measurements on mobile network coverage and service quality in Taiwan. The work which is being caried out by the Telecom Technology Center (TTC) involves fixed location measurements by members of the public and drive testing across the whole of Taiwan. Aside from download and upload speeds, other indicators that are tracked include voice call performance for circuit-switched fall back (CSFB) and VoLTE.[165]

Separately the MNOs also publish information on network coverage, quality of reception and locations of Wi-Fi hotspots.[166] The NCC also tracks the number and location of base stations for each MNO.[167]

In early 2021, the NCC announced that the five MNOs will need to include information on their websites such as mobile broadband speeds, coverage levels, service prices, complaints response times, and the mechanisms used

[162] APT/GT, 10 September 2021, "Shareholder members – top 10 shareholders." Available (in Chinese) at: https://www.aptg.com.tw/corporate/apt/shareholding/

[163] Fair Trade Commission, 4 August 2021, "The first domestic cooperation case of FarEast and Asia Pacific 3.5 GHz frequency and network sharing, the FTC will not prohibit it, but the additional supplementary payment applied." Available (in Chinese) at: https://www.ftc.gov.tw/internet/main/doc/docDetail.aspx?uid=126&docid=16798

[164] Taipei Times, 11 September 2020, Telecoms can drop 3G by 2024, must protect user rights. Available at: https://www.taipeitimes.com/News/taiwan/archives/2020/09/11/2003743213

[165] TTC, 2021, "Appendix III. 2020 Mobile measurement and communications services (voice services and data services) measurement results." Available (in Chinese) at: https://speed.ttc.org.tw/uploads/202104211340_85886.pdf

[166] The information can be accessed at http://freqgis.ttida.org.tw/freqgisindex/

[167] The information can be accessed at https://graphwebn.ncc.gov.tw/index.php

to protect subscriber's personal data. [168] The information disclosure requirement and self-evaluation of their service provision is expected to be introduce by January 2022.

2.7.3.5 Support for 4G and 5G development

The Taiwan government had sought to promote the deployment of 4G network infrastructure with the implementation of promotional policies that include the following. [169]

- Inter-ministerial awareness campaigns concerning electromagnetic waves;[170]
- Continual promotion of the co-location of mobile communications platforms;
- Release of public land for base stations;
- Establishment of next generation electric wave monitoring system; and
- Continual spectrum planning for the future.

No explicit financial support was provided for 4G infrastructure deployment though there were financial grants for demand-side initiatives and development of 4G applications and services.[171] The impacts of these demand-side measures and programmes are unclear. With 5G there has been a shift towards more support and incentives relating to infrastructure and network deployment.

In 2019 and prior to the launch of 5G services, the Taiwan government announced the 5G Action Plan and the allocation of NT$20.4 billion over a four-year period (2019 to 2022) for the development of 5G mobile networks.[172] The 5G Action Plan was part of the government's broader masterplan for digital development and innovation – the Digital Nation and Innovative Economic Development Program (DIGI+).[173]

In February 2020, the NCC announced a 5G first-wave programme and targets in order to accelerate the rollout and take-up of 5G. This aimed to encourage MNOs to deploy 5G in particular areas and hubs within a specific timeframe (1.5 years, 2.5 years or 3.5 years). The areas and venues identified are either high density areas to provide capacity to subscribers (e.g., in shopping centres or at sporting venues) or industrial use cases (e.g., for smart transport or telemedicine use).

In October 2020, proposals for subsidising the rollout of 5G in Taiwan were published. The subsidy would offer NT$26.65 billion to operators with the purpose to accelerate 5G network deployment and to promote the development of 5G applications in Taiwan.[174] The justification was to mitigate the high build-out costs in the initial phase of 5G rollout, accelerate 5G adoption and promote the development of 5G applications.

It is understood that this would support the cost of additional base stations (those not originally included in MNOs business plans submitted prior to the 5G spectrum auction). Figure 2.42 summarises the proposed subsidy and its allocation over five years.

[168] Telegeography. 29 March 2021, Taiwanese operators face requirement to disclose important service info online from 2022. Available at: https://www.commsupdate.com/articles/2021/03/29/taiwanese-operators-face-requirement-to-disclose-important-service-info-online-from-2022/
[169] NCC, 2021, Introduction – The Development of Mobile Communications in Taiwan. Available at: https://www.ncc.gov.tw/english/content.aspx?site_content_sn=317&is_history=0
[170] These inter-ministerial campaigns include reassuring the public about the safety of electromagnetic waves. An example new item from the NCC's website is published on the following link: https://www.ncc.gov.tw/english/news_detail.aspx?site_content_sn=360&sn_f=5309
[171] BOST, 20 June 2014, "Promote 4G mobile broadband services for public, and assist in industrial upgrading and development." Available (in Chinese) at: https://bost.ey.gov.tw/Page/64067066A4E568B3/f2fd80ff-245c-4b31-b126-a8f234d8ce28
[172] DIGI+,5 July 2019, Taiwan's 5G action plan. Available at: https://digi.ey.gov.tw/en/BD28C14C8FBBF163/51dc966f-7d18-4178-8877-0e39eb44308d
[173] DIGI+ Taiwan, 2021. Available (in Chinese) at: https://digi.taiwan.gov.tw/
[174] Details of subsidy plan is available (in Chinese) at https://www.ey.gov.tw/File/B4F09E52231984B6

Figure 2.42: Taiwan 5G rollout subsidy

Year	Funding available	Outcome with period
Year 1 – 2021	NT$9.92 bn	Up to 50% coverage of non-rural population
Year 2 – 2022	NT$5.57 bn	Up to 60% coverage of non-rural population
Year 3 – 2023	NT$ 5.56 bn	Up to 70% coverage of non-rural pop
Year 4 – 2024	NT$2.59 bn	Up to 80% coverage of non-rural pop; 40% of new network (including base stations) to be sourced locally
Year 5 – 2025	NT$3 bn	Up to 80% coverage of non-rural pop; 40% of new network (including base stations) to be sourced locally

There is also a separate subsidy scheme to enhance mobile broadband (4G and 5G) deployment in rural areas with a total of NT$1.2 billion allocated over 5 years (2021 to 2025).[175]

2.7.4 Service pricing

As discussed above there is significant price competition in the Taiwan market – 4G post-paid SIM-only plans can be as low as NT$199 (approximately £5.20) for 3GB data and up to NT$999 (£26.10) for unlimited data and voice.[176] Currently 5G plans are priced at a premium compared to 4G. For example CHT's post-paid SIM-only plans start at NT$599 (£15.70) for 12GB data and up to NT$2,699 (£70.60) for unlimited data.[177]

Network speeds are commonly advertised as part of mobile tariffs though mobile tariffs are predominantly a capped data allowance offering a lower network speed (e.g., 500 Mbps, which is the lowest speed offered amongst 5G packages) or an unlimited data allowance with faster speeds (e.g., 1 Gbps or 1.5 Gbps).[178] Faster network speeds are advertised as part of larger data allowances and higher quality packages (e.g., sharing of data allowances, no speed throttling). It is important to note, however, that advertised 5G network speeds are a maximum and these exceed the network speeds recorded by Opensignal and summarised in Section 2.7.2.

Data speed throttling is a common feature of 4G mobile packages once consumers have exceeded their data allowance, and the limitations on speeds are included as part of the tariff information advertised. For 4G this practice works more for quality and network management purposes, particularly given the majority of mobile users in Taiwan are on 4G with unlimited data plans. For 5G MNOs appear to be using this as a pricing strategy at present, with different 5G price tiers offering a differentiated speed reduction once the data allowance has been reached as shown in Figure 2.43. For example, a user on a lower-priced 5G plan will be limited to 5 Mbps after using up the data allowance, while those on the more expensive tiers would not be subject to speed limitations regardless of the amount of data consumed.

[175] Details of the rural areas' subsidy. Available at: https://www.ey.gov.tw/File/987CA5D2AF084951
[176] Based on Plum survey of MNO retail offerings.
[177] CHT, 2021, Post-paid Services rates cards: https://www.cht.com.tw/en/home/cht/about-cht/products-and-services/mobile/post-paid-services
[178] Based on Plum survey of MNO retail offerings.

Figure 2.43: Example of 5G price plans in Taiwan

5G Sim Only Plan		Plan 599	Plan 799	Plan 999	Plan1199	Plan 1399	Plan 1599	Plan 1799	Plan 2699
Monthly Fee (NT$)		599	799	999	1199	1399	1599	1799	2699
Contract Period		12/24 months							
Data Usage	Allowance	12GB	18GB	30GB	50GB	100GB	150GB	200GB	500GB
	Bonus Data during Contract Period	24GB	36GB	60GB	100GB	Unlimited			
	Thereafter Charge (Thereafter usage has no extra charge.)	The speed will be restricted up to 5 Mbps		The speed will be restricted up to download 50 Mbps / upload 20 Mbps.					

Source: Chunghwa Telecom website (accessed 12 October 2021)

2.7.5 Appraisal

In Taiwan the main driver for high quality mobile services in recent years has been the fierce price competition among the MNOs and 25% decline in ARPU per mobile connection since 2016. While Taiwan launched 4G in 2014 which is later than most other advanced markets, there were five MNOs competing across the whole market at the network level. It was also one of the earliest markets to offer low-cost unlimited data plans. This led to a long-running price war among the five MNOs which benefited consumers in terms of low prices and generous data allowances.

To meet the growing data demand triggered by the availability of low-priced mobile plans, the NCC has adopted a number of measures in response to spectrum constraints and to ensure that MNOs are able to meet consumer needs. These have included:

- clearance and release of the 2600 MHz band;
- back-to-back phasing out of 2G and 3G in 2017 and 2018 to allow refarming to 4G; and
- changes to the regulatory framework to allow more flexibility for network and spectrum sharing, and secondary spectrum transactions.

So far MNOs in Taiwan have been able to maintain high quality as reflected in the strong Opensignal performance ratings. As a whole, Taiwan has the highest cell density among the markets considered in this study which would suggest that the operators are able to accommodate the growing traffic load despite having a lower amount of spectrum than their counterparts elsewhere. The migration of all mobile data traffic to 4G has also helped in this regard by maximising the efficiency of spectrum utilisation.

On the other hand, the bruising price war has raised concerns over revenue growth, long term sustainability and the development of 5G in Taiwan. The government, as part of the broader Digital Nation and Innovative Economic Development Program (DIGI+), has responded by introducing different support schemes for 5G and offering financial incentives for MNOs to accelerate 5G deployment over the next five years.

3 Fixed-mobile convergence

3.1 Definition

Fixed-Mobile Convergence (FMC) can take several forms, from network convergence through to convergence at the retail level, delivered through the bundling of retail packages. The focus of analysis for this report is on the latter. Converged offers to customers can take several forms, including:

- A package with fixed and mobile service components sold as a single entity and differentiated from separate fixed and mobile subscription packages.
- A subscriber to a fixed or mobile package being able to purchase an additional package at a discount only available for this purpose, leading to a cheaper combined package but with two contracts.

Case studies are provided for France, The Netherlands, Spain and Portugal. In addition to the FMC examples, we have also considered one case (Finland) where a high level of Fixed-Mobile Substitution (FMS) has occurred.

3.2 Take-up of fixed-mobile bundles and UK position

Detailed cross-country information on take-up of fixed-mobile bundles is limited. Based on available survey data from the European Commission and Ofcom, fixed-mobile bundles appear to be less prevalent in the UK to date than in the other FMC markets as shown in Figure 3.2. Ofcom consumer survey data indicates that while 80% of UK adults have purchased two or more communications services from the same provider as part of a bundle in Q1 2021, only 17% of UK adults purchase a combination of fixed and mobile services from the same provider (or 18% of UK mobile users purchase a combination of fixed and mobile services from the same provider).[179] Across the European markets examined, household take-up of communications service bundles that include a mobile service,[180] ranges from 37% in France to 66% in Spain.[181]

Figure 3.1: Households subscribing to two or more services (including a mobile service)

Market	2017	2021	Change
Finland	52%	43%	↓ 9%
France	42%	37%	↓ 5%
Netherlands	35%	40%	↑ 5%
Portugal	39%	50%	↑ 11%
Spain	53%	66%	↑ 13%

Notes: For Finland, France, Netherlands, Portugal and Spain, data is from Eurobarometer.
Source: European Commission Special Eurobarometer 510 (June 2021) and Special Eurobarometer 462 (July 2018).

[179] Ofcom Technology Tracker 2021, 14th January to 31st March 2021. Table 156. Available at https://www.ofcom.org.uk/__data/assets/pdf_file/0015/219102/technology-tracker-2021-data-tables.pdf
[180] While not specifically stated in the survey, it is expected most of these bundles would also include a fixed broadband service. While it is possible that there are bundles comprising a mobile service but not fixed (e.g. a mobile and pay TV bundle), such service bundles are not commonly observed or available in most markets.
[181] European Commission, June 2021. E-Communications in the Single Market. Special Eurobarometer 510. Available at https://europa.eu/eurobarometer/surveys/detail/2232

The UK is unlike the selected FMC markets in that there are established mobile operators such as Three and O2, prior to its merger with Virgin Media, which are predominantly standalone mobile operators. This is a likely reason for the lower take-up of bundles that include a mobile service. We observe lower levels of ultrafast broadband coverage in the UK compared to the other FMC markets – as of 2020, household coverage of very high capacity networks[182] is 10% in the UK, compared to over 80% in Portugal, Netherlands and Spain. In markets like Portugal and Spain, the expansion of ultrafast broadband has facilitated growth in the take-up of IPTV services which are often sold as multi-play bundles including fixed and mobile services.

In the UK, the expansion of fibre broadband, along with technology synergies between 5G and fixed networks, will offer more opportunities for competitive converged service offerings over the coming years. At the same time, the growing popularity of OTT video services, such as Netflix, Amazon Prime Video and Disney+, is diminishing the attractiveness of premium TV bundles. In this regard, the UK is relatively advanced – 60% of UK households were subscribers to video-on-demand services as of Q3 2020, higher than the proportion of pay-TV households (48%).[183] This may increase the attractiveness of simpler service bundles (without TV), and lower barriers to entry for challenger operators, who could seek to target specific market segments through partnerships with wholesale networks and third-party OTT providers.

3.2.1 Pricing of fixed-mobile bundles

In order to allow for a like-for-like comparison of converged offers in markets where mobile and fixed broadband services are bundled and where they are not, we consider the pricing of selected fixed-mobile bundles in four FMC markets and the UK. The prices are based on the study by Empirica and TÜV Rheinland (2020) for the European Commission. For our purposes the following baskets were selected:

- Bundle 1: 12-30 Mbps fixed internet with fixed phone with 1-SIM, 30 calls and 1 GB mobile data
- Bundle 2: 100-200 Mbps fixed internet with fixed phone with 1-SIM, 300 calls and 5 GB mobile data
- Bundle 3: >200 Mbps fixed internet with fixed phone and TV with 1-SIM, 300 calls and 5 GB mobile data

The prices reported are based on the least expensive converged offers or combinations of standalone services commercially available in the market.[184] It should also be noted that the study was carried out in 2019 and the analysis was based on a snapshot of prices over a three-week period in October 2019 which may not be representative of the current market situation.[185]

Figure 3.2 presents the comparisons. It is notable that the lowest-priced fixed-mobile service combinations comprise a mixture of bundled service offerings from the same provider as well as standalone offers from separate operators. Thus, while fixed-mobile bundles are usually offered at a discount by operators compared to purchasing the equivalent fixed and mobile services individually, it is not always the case that fixed-mobile bundles by the same supplier offer the best value for consumers in terms of price.

[182] This is defined as Fibre-to-the-home (FTTH), Fibre-to-the-building (FTTB) and cable DOCSIS 3.1.
[183] Ofcom, 5 August 2021, Media Nations: UK 2021. Available at https://www.ofcom.org.uk/__data/assets/pdf_file/0023/222890/media-nations-report-2021.pdf
[184] These are not available for purchase from a single provider as such.
[185] For example, the current prices of triple-play bundles by Virgin/O2 in the UK range from £40 to £99 (as of November 2021).

Figure 3.2: Comparison of lowest-priced fixed-mobile services (EUR PPP)

Market	Bundle 1	Bundle 2	Bundle 3 (with TV)
France	28.41 (Free)*	38.07 (Bouygues/SFR)	38.53 (Bouygues/SFR)
Netherlands	46.51 (KPN/Tele2)	70.19 (KPN/Tele2)	81.86 (KPN/Tele2)
Portugal	55.43 (Vodafone/MEO)	73.81 (Vodafone/MEO)	76.11 (Vodafone/MEO)
Spain	44.9 (Masmovil)*	54.46 (Masmovil)*	87.00 (Vodafone, inc Ono)*
UK	34.26 (Talk talk/Telefonica)	58.48 (Virgin /Three)	115.26 (Virgin Media)*
EU27 average	40.23	58.39	72.76

Note: * converged bundle available and at lower priced than a combination of individual mobile and fixed packages.
Source: Empirica and TÜV Rheinland (2020). Mobile and Fixed Broadband Prices in Europe 2019. Plum analysis.

On the whole France has the lowest-priced fixed-mobile bundles and Portugal the most expensive (Bundles 1 and 2). For fixed-mobile bundles with TV (Bundle 3), prices are highest in the UK.

The gap between the Bundles 1 and 3 is the smallest in France, and largest in the UK. There could be a number of reasons, including consumer preferences, operators' pricing strategies and the type of content included in the TV bundle. Excluding TV, the price differential between Bundles 1 and 2 is smallest in France and Spain (around 10 EUR PPP) and largest in Netherlands and UK (around 24 EUR PPP).

3.3 Summary of FMC drivers and impacts

Figure 3.3 summarises the key findings from the fixed-mobile case studies. There is no consistent reporting of the adoption of fixed-mobile bundles across the markets surveyed. However, based on Eurobarometer and available data from national regulators, France, Netherlands, Portugal and Spain all have relatively high take-up of fixed-mobile and other bundled services, compared to the UK. The figures appear to indicate that in each of these markets around one-third or more of all households are subscribers to some of type of fixed-mobile service bundle from a single operator, with such complex bundles, often including TV services, particularly popular in Portugal and Spain. On the other hand, Finland is an example of fixed-mobile substitution with a significant proportion of mobile broadband-only households compared to the other markets.

Figure 3.3: Key findings from FMC case studies

Market	Take-up of fixed-mobile bundles? Impact on switching?	Business models? Own network or wholesale access?	Commercial advantages of own mobile and fixed networks?
Finland	• Fixed-mobile substitution reflected in high proportion of mobile broadband-only households (36%). • Driven by unlimited data bundles and larger mobile than fixed NGA footprint.	• MNOs operate nationwide and as the main mobile/fixed ISPs. • There is also a patchwork of larger and smaller regional fixed network providers.	• The three MNOs benefit from nationwide operation and ability to benefit from their scale and the consistent scope of retail propositions they can offer. • Regional fixed operators are more driven by local conditions and to some extent may be restricted by differences in wholesale pricing between urban and rural areas.
France	• 37% of French households take mobile services as part of a bundle, and 49% take fixed internet access as part of a bundle. • ARCEP data indicates that, as of March 2021, 30% of France's 70m post-paid SIM cards are coupled with fixed access.	• All 4 MNOs own (or co-own) fibre infrastructures, with significant shares in fixed networks. • Supported by symmetric regulation for FTTP, and access to wholesale or public FTTP networks or Orange's mobile network.	• Orange has largest mobile share but declined over last 10 years. • Notable that Free Mobile has chosen to deploy its own FTTP network.
Netherlands	• 40% of households take mobile services as part of a bundle, and 86% take fixed internet access as part of a bundle. • Fixed-mobile bundles are over a third of bundled subscriptions. • Limited information on switching but observe consumers switching to simpler bundles (fixed-mobile or dual play (2P)).	• Three main MNOs offer fixed broadband services via own networks. • KPN and Ziggo have largest fixed footprints, and KPN must offer wholesale fixed access. Used by T-Mobile and some MVNOs for bundle offers.	• Large number of mergers between fixed and mobile operators seem to indicate advantages of own networks. • Cable/pay-TV important for bundled offers though recent shift to simpler bundles is a likely reflection of increased take-up of OTT SVoD services.
Portugal	• High take-up of bundled services – 50% of households take mobile services as part of a bundle, and 68% take fixed internet access as part of a bundle. • 4P/5P offers account for 50.3% of bundle subscriptions (these bundles include fixed-mobile services).	• Mix of business models. MEO access to Grupo Altice fixed network. NOS has access to own network and agreed to deploy FTTP with rival Vodafone. Also 2 MVNOs from Grupo Apax that offer fixed services (hosted by MEO for mobile and provided by other wholesale access for fixed).	• Some commercial advantage suggested as MEO/Grupo Altice holds the largest shares in fixed and mobile. • Wholesale access provisions allow operators to use other networks. • Pay-TV and other bundled services are important determinants of take-up.

Market	Take-up of fixed-mobile bundles? Impact on switching?	Business models? Own network or wholesale access?	Commercial advantages of own mobile and fixed networks?
Spain	• High take-up of bundled services – 66% of households take mobile services as part of a bundle, and 57% take fixed internet access as part of a bundle. • Fixed-mobile bundles represent 40.9% of all bundle subscriptions in 2020; fixed-mobile with TV is 39.1%.	• Market consolidation means operators each have some of their own fixed and mobile infrastructure. However, government promotion of infrastructure sharing and wholesale access means operators use own network and wholesale access.	• Potentially limited given Government push for shared infrastructure use and fibre-sharing/co-investment between operators.

We observe high take-up of fixed-mobile offers where available though in Spain, Portugal and the Netherlands the pull of fixed-media (including pay-TV or OTT VoD services) bundle is stronger. There is limited information on consumer switching and churn from fixed-mobile and other bundles. In France, however, take-up of bundles with fixed broadband has slightly declined which may be a response to the introduction of shorter contract durations (consumers less tied in) and increased mobile competition. There has been marginal growth in take-up of bundled services, though there has been a significant shift away from triple play bundles and towards simpler fixed-mobile and dual play bundles. It is unclear whether this results from the regulator's efforts to promote competition and switching, or is due to substitution between traditional pay-TV (e.g., cable, satellite, IPTV) offered by telecoms operators and VoD services by global streaming platforms.[186]

Finland is the notable exception as a high proportion of households use only mobile broadband at home (fixed-mobile substitution). Operators advertise home mobile broadband as a separate service to mobile and fixed broadband, and this is in part driven by the popularity of unlimited data mobile offers and a 4G mobile footprint, which exceeds that of 100 Mbps capable fixed networks. While fixed-mobile operators are able to offer hybrid home broadband,[187] such products are still relatively uncommon in the selected FMC markets.

In terms of business model, fixed-mobile providers tend to combine their own infrastructure and wholesale access. In France and Netherlands, all MNOs have some fixed infrastructure that they use to provide fixed-mobile services and wholesale access regulation ensures smaller players access to larger fixed networks.

A similar dynamic is observed in Portugal and Spain where there has been a greater focus on infrastructure sharing to deliver gigabit-capable broadband and full-fibre networks, as well as a number of independent wholesale networks operating in some areas. The strong presence of fixed-mobile resellers is notable in these two markets, with these players replicating the design of network operators' bundles rather than operating as a MVNO or fixed ISP.

Whilst those operating their own fixed and mobile networks may experience some commercial advantage, it is difficult to assess the extent of this. Each of the FMC case study markets impose some wholesale access regulation and this tends to be symmetric regulation for wholesale access on operators with fibre networks. The access approach is further strengthened by the presence of independent wholesale networks in Portugal and

[186] It is notable that in Europe, unlike the US where pay-TV has experienced a significant decline as a result of competition from online streaming services, pay-TV penetration has so far held up against online streaming, and in some cases still growing. Source: Economist. Cable ties: As Americans cut the cord, Europeans sign up for more pay-TV, 11 September 2021. https://www.economist.com/business/2021/09/11/as-americans-cut-the-cord-europeans-sign-up-for-more-pay-tv

[187] For example, BT and Vodafone in the UK are offering hybrid broadband which uses their 4G networks to ensure a continuous and reliable connection. See https://www.bt.com/exp/halo and https://newscentre.vodafone.co.uk/press-release/unbreakable-broadband-without-breaking-the-bank-vodafone-pro-broadband/

Spain and cooperation between smaller regional players in the Netherlands and Spain. This provides MNOs and MVNOs without fixed networks the opportunity to provide fixed-mobile bundles.

Orange is the largest mobile and fixed provider in France. However, its mobile market share has deteriorated in the last ten years, since the entry of Free Mobile, which suggests there is no significant commercial advantage to being a fixed-mobile provider. Free Mobile has also invested in FTTP networks, suggesting that the smaller player anticipates some advantage from having some of its own fixed infrastructure.

There are three significant conclusions from the FMC case studies.

- First, we do not observe mobile-only or fixed-only players in these markets. The markets tend towards convergence and non-converged operators will replicate fixed-mobile and bundled service offerings through wholesale access (for example, fixed operator Grupo NOWO which has launched two MVNOs) or merging entities (as observed in the Netherlands).

- Second, one of the key commercial advantages relates to pay-TV services which are offered in bundles and tend to be less substitutable between operators.

- Third, while fixed-mobile bundles are usually offered at a discount by operators compared to purchasing the equivalent fixed and mobile services individually, it is not always the case that fixed-mobile bundles by the same supplier offer the best value in terms of price as illustrated in the price comparisons in Figure 3.2. Depending on the nature of the bundle (e.g., low or high allowance, or if TV or video services are included) consumers may be able to find equivalent individual fixed and mobile packages at lower prices. There are many factors that drive the pricing of bundles including consumer preferences, convenience, quality of service, pricing strategy and the type of TV content included in the bundle.

This is unlike in the UK where there are established operators such as Three and O2, prior to its merger with Virgin Media, which are predominantly pure-play mobile players.

3.4 Finland

Motivation for selection: High substitution between fixed and mobile broadband services, no bundling offered.

This case study builds on the Finland high quality network case study, presented in Section 2.1.

Key market & supply chain features	
Mobile network operators (subscriber share)	Elisa (35-40%), Telia (30-35%), DNA (25-30%)
Mobile virtual network operators	6 MVNOs: Moi, Aiva Mobile (MTT), Ainacom, Globetel, Satera, Tismu
Other notable players in broadband supply chain	Elisa, Telia and DNA all operate as fixed ISPs, in addition to the Finnet Association (central organisation and co-operative forum of local ICT companies; <10% share of fixed connections) and other small regional players such as Cinia (purchased regional Oulu-based ISP and wholesaler Netplaza in 2018).
LTE coverage (% population)	100% (2021 Q2)
5G coverage (% population)	64.7% (2021 Q2)
Fast broadband coverage (% households)	75% (2020)
Very High Capacity Network (VHCN) coverage (% households)	58% (2020)
Mobile data usage (GB/month/sub)	30.99 (2020)
Fixed data usage (GB/month/sub)	Not available
Mobile broadband penetration (% population)	161.82 % (Q2 2021)
Fixed broadband penetration (% households)	113% (2020)
Population (million)	5.53 (2020)
Rural population (%)	14.5% (2020)
Households (million)	2.51
Land Area (sq.km)	303,920 (2020)
GDP per capita (US$, current)	49,041 (2020)

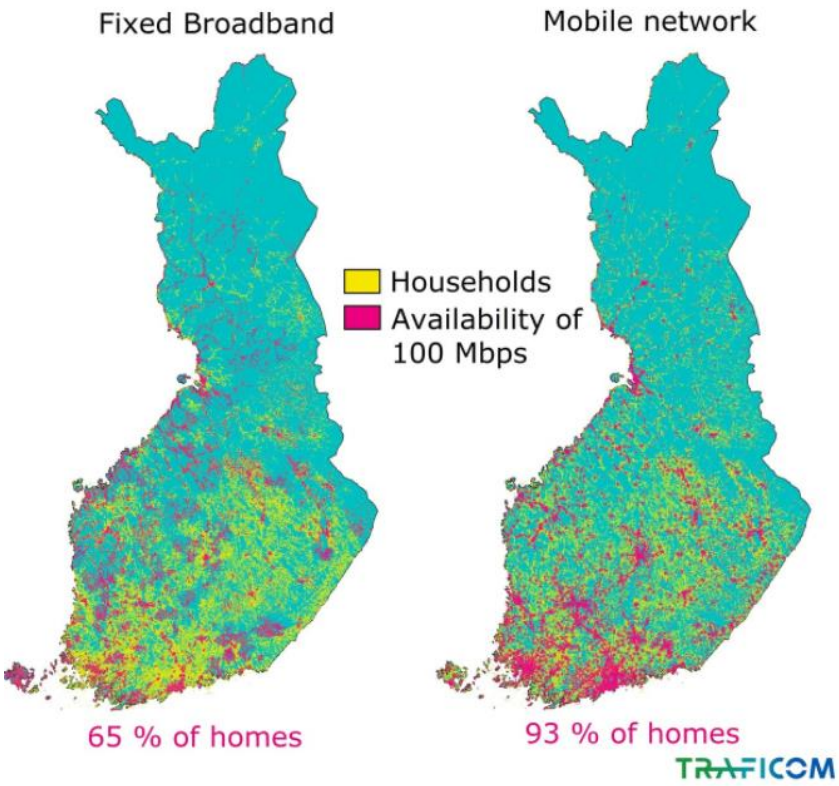
Note: Fast broadband (NGA) defined as at least 30 Mbps download. VHCN comprises FTTH, FTTB and Cable Docsis 3.1.
Source: Plum, GSMA Intelligence (2021 Q2), Opensignal (2021 Q1 values), World Bank (2020 values), OECD (2020 values), European Commission DESI (2020), ITU (2020).

3.4.1 Market overview

More than 1.6 million households in Finland have fixed broadband connections compared with 6.5 million mobile subscriptions, a quarter of which were mobile-only 4G/5G subscriptions. In May 2021, the Finnish regulator Traficom reported that 65% of households had access to fixed broadband connections with a download speed of 100 Mbps or more, and 93% of households had access to an equivalent mobile broadband

connection.[188] There are, however, high disparities in the availability of services between main residences and summer houses; 100 Mbps mobile connections were only available to 43% of Finnish summer homes.

Figure 3.4: Availability of 100 Mbps fixed and mobile connections in Finnish households



Source: Traficom.

There are three established MNOs in Finland – Elisa, DNA and Telia. Each MNO also operates as an ISP providing home broadband service, primarily fixed (fibre, DSL or cable) networks and 5G/mobile broadband services, as well as fixed telephony and IPTV subscriptions. Whilst the operators have national mobile networks, each only has regional fixed networks (no national fixed network). Operators therefore have limited reach to offer fixed services outside of their network areas or where wholesale fixed access is not a regulatory obligation on other regional fixed ISP operators.

The operators' offerings are further discussed below.

- **Elisa** is the incumbent telecoms operator and is currently the largest MNO (35-40% share as of 2021 Q2)[189] and the second largest fixed network operator (30% share of fixed broadband subscriptions as of 2021 Q2).[190] Originally a fixed network provider, Elisa launched 2G/GSM serviced in Finland in 1991 (branded as *Radiolinja*). In 2002, Elisa started to cooperate with Vodafone Group to develop its mobile

[188] Traficom, 4 May 2021, Reliable network connections a requirement for smooth telecommuting – the importance of broadband network development set to increase in the future. Available at: https://www.traficom.fi/en/news/reliable-network-connections-requirement-smooth-telecommuting-importance-broadband-network
[189] Share of mobile connections for each operator sourced from GSMA Intelligence.
[190] Traficom, 19 December 2018 (updated 30 September 2021), Fixed broadband subscriptions Available at: https://www.traficom.fi/en/statistics/fixed-broadband-subscriptions

subsidiary.[191] Elisa later acquired smaller rival operator Saunalahti in 2005.[192] As a condition of the acquisition, the Finnish Competition Authority required that Elisa sold the Saunaverkko network (including customer agreements) in the Tampere, Jyväskylä and Riihimäki regions and that the Saunaverkko network (exclusive of customer agreements) would be sold in the metropolitan Helsinki area.[193]

Elisa offers several different telecom services including mobile and mobile broadband services (*Elisa Saunalahti*), virtual communications solutions, AI automation for mobile networks and Elisa Smart Factory services. Elisa also produces Finnish drama which is available through its IPTV and on-demand platforms (*Elisa Viihde* and *Viaplay*).

- **Telia** is the second largest MNO (30-35% share of mobile connections as of 2021 Q2) and a provider of fixed services (26% share of fixed broadband subscriptions as of 2021 Q2). It offers mobile subscriptions as well as a range of fixed internet services, including fixed (fibre or DSL) broadband, 5G home internet (FWA) and mobile broadband services for residential subscribers. Telia is currently offering dual-play subscriptions for 4G or 5G mobile services combined with free *C More* entertainment (on-demand TV and film) for mobile and other smart devices.[194]

  The current Telia company is the result of a merger in 2002 between Swedish Telia AB and Finland's Sonera, consolidating the companies holdings throughout the Scandinavian and Baltic regions.[195] Telia AB was active in the Finnish market as a "no frills" MVNO, known as Tele Finland, and Sonera was the second largest MNO in Finland and a provider of fixed broadband and telephony services.[196] As such, the brand's mobile and fixed offerings were branded as Sonera until 2017 when the company rebranded to Telia.[197]

- **DNA** is the third largest MNO (25-30% share of mobile connections as of 2021 Q2) and provides home broadband and cable/IPTV services. As of June 2021, the operator has overtaken Telia to be the largest provider of fixed broadband subscriptions with a market share of 32%. DNA is a wholly owned subsidiary of Norwegian operator Telenor, which acquired a majority stake in 2020.[198] DNA evolved from the mobile division of the Finnet group, launching as DNA Finland in 2000. In 2003, DNA acquired parts of Telia AB's mobile communication, distribution and network businesses operating in Finland. In the 2010s, DNA focused on developing its cable TV and broadband businesses with a number of acquisitions; for example, DNA acquired Sanmoa Group's cable TV and broadband business in 2010.[199] In April 2015, the company combined its mobile, TV and broadband, and business units and relaunched all services under the current one-brand DNA.

The three main operators in Finland, have a combined share of 88% of the fixed broadband market in terms of subscriptions.[200] Members of the Finnet group[201] which was originally founded in 1921 as an advocacy and

[191] RCR Wireless, 21 February 2002, Elisa enters collaboration agreement with Vodafone. Available at: https://www.rcrwireless.com/20020221/archived-articles/elisa-enters-collaboration-agreement-with-vodafone
[192] Telecompaper, 8 November 2005, Elisa acquires 96 percent of Saunalahti shares. Available at: https://www.telecompaper.com/news/elisa-acquires-96-percent-of-saunalahti-shares--494928
[193] Elisa, 26 October 2005, Finnish Competition Authority accepted Saunalahti acquisition. Available at: https://news.cision.com/elisa-oyj/r/finnish-competition-authority-accepted-saunalahti-acquisition,c2817446
[194] Telia Dot mobile and C More TV offer: https://www.telia.fi/dot/5g/ (accessed 31/08/2021).
[195] Telia, 2021, Telia+Sonera=TeliaSonera, Available at: https://www.teliacompany.com/en/about-the-company/history/telia-sonera-and-teliasonera/
[196] Reference for Business, 2021, TeliaSonera AB – Company Profile., Informations, Business Description, History, Background Information on TeliaSonera AB. Available at: https://www.referenceforbusiness.com/history2/99/TeliaSonera-AB.html
[197] Telia, 23 March 2017, Sonera becomes Telia. Available at: https://www.teliacompany.com/en/news/press-releases/2017/3/sonera-becomes-telia/
[198] YLE, 9 April 2019, "DNA is fast moving to Norwegian ownership – Telenor acquisition brings hundreds of millions in profits to Finnish owners." Available (in Finnish) at: https://yle.fi/uutiset/3-10729245
[199] tivi, 31 May 2010, "DNA buys Welho subscriptions." Available (in Finnish) at: https://www.tivi.fi/uutiset/dna-ostaa-welhon-liittymat/fd92a7c1-e2c3-3c11-9916-4ab4844f59a7
[200] Traficom, 19 December 2018 (updated 30 September 2021), Fixed broadband subscriptons Available at: https://www.traficom.fi/en/statistics/fixed-broadband-subscriptions
[201] Finnet, 2021. https://www.finnet.fi/

cooperative body for regional telecommunications companies, has a combined market share of 8%. There are also a number of regional fixed network providers that offer fixed broadband services. The impact of the fixed and mobile market structures is further discussed in Section 1.2.

Unlike the other FMC case studies, the MNOs/ISPs offer fixed and mobile services as standalone services. Fixed-mobile plans are not offered; however, we note that existing customers may be offered a discount if they subscribe to a second service from the same provider (discount usually applied to mobile tariff). There is no regulatory restriction on the provision of bundles.

3.4.2 Market structure

Historically, fixed copper networks in Finland were provided by approximately 20 regional fixed operators. These networks are now being upgraded to fibre, the focus of which is rollout in urban areas with higher population density. Overbuild of fibre networks is also being observed in some areas, resulting in competition in fixed infrastructure provision. In some areas where copper access has been retired, some subscribers have shifted to mobile broadband services, particularly in rural areas where there is currently no fibre rollout. In some places, mobile broadband (or FWA) services are the only option for home internet connectivity. In December 2020, Telia started offering[202] 5G FWA services aimed at the three quarters of detached houses in the country that lack fibre connectivity. The price of the service has been set to €39.90 for up to 400 Mbps or €44.90 for up to 1 Gbps.

Another feature of the Finnish market is that individual end-users are not the only buyers of fixed services. There are legislative provisions to require housing associations that own/manage apartment blocks and multiple-dwelling buildings to provide fixed connectivity. The housing association will often negotiate with fixed ISPs for the best deal, and this is typically a basic package offered to all residents (e.g., 10 Mbps per connection). Residents can opt into these services and the charges are paid to the housing association (similar arrangements exist for cable/IPTV services). Residents are also free to select their own provider and service package; though this will be on an individual household basis.

3.4.3 Policy and regulatory environment

The following section outlines regulation and policy relevant to fixed network provision. For regulation that specifically applies to mobile services, refer the Finland HQN case study, Section 2.4.3.

3.4.3.1 Fixed access regulation

As an EU country Finland is subject to the application of SMP to markets set out in the Recommendation on Relevant Markets. On the 31st December 2020 the European Commission in its overview of Article 7 cases, noted that for Markets 3a, 3b and 4 (wholesale local, central and high quality access), there is partial competition with partial ex-ante regulation.[203] Decisions on SMP are more complex given the nature of the regional fixed network structure in Finland and the presence of a number of smaller regional operators.

The 20 or so network operators involved in the provision of fixed services are subject to SMP obligations in one or more of the markets mentioned above – the key operators being Telia, Elisa and DNA. There have been ongoing issues with the assessment of wholesale relevant markets in Finland by Traficom and its predecessor regulator Ficora. In 2017 the European Commission raised concerns regarding the market assessment process

[202] Trafica, 16 December 2020, Telia Finland Offers Hone 5G Fixed Wireless Internet. Available at: https://tarifica.com/telia-finland-offers-home-5g-fixed-wireless-internet

[203] European Commission, 3 July 2017, European Commission starts investigation into the price regulation proposed by Finnish telecoms regulator on broadband copper markets. Available at: https://digital-strategy.ec.europa.eu/en/news/european-commission-starts-investigation-price-regulation-proposed-finnish-telecoms-regulator

that led Ficora to propose not imposing price regulation on the copper networks of Telia, Elisa and DNA, as well as to set the rate of virtual unbundled local access (VULA) at non-regulated copper prices. Lighter obligations were proposed for 18 smaller fixed network operators. Ficora also proposed to lower fibre access charges, but concerns were identified on the price differential that might between arise urban and rural fibre prices. Ficora withdrew the proposed measures following the Commission's investigation.

There have also been proceedings in the Finnish Supreme Administrative Court, on the application of SMP to Elisa in the relevant markets for wholesale high-quality access networks; it was considered that Elisa would have SMP in the wholesale market for high-quality access at fixed location in 98 municipalities in Finland. The court repealed Traficom's SMP decision and referred the matter back to Traficom in December 2019.[204]

3.4.3.2 Initiatives for NGA provision

In October 2018, the Ministry of Transport and Communications published the Finnish Digital Infrastructure Strategy.[205] This document lays out the objectives for the development of the country's digital infrastructure by 2025, as well as how to achieve these objectives.

As of January 2021, the Act[206]on Support for Broadband Construction has entered into force.[207] The government initially allocated a €5-million budget to support the construction of high-speed networks in in areas that will not have commercial broadband before 2025. In a press release,[208] Traficom has indicated that the requirements for eligible broadband connections are technology-neutral and that they can be implemented with either a fixed or FWA technology.

Recently, the Ministry published a draft law amending the Act and the related draft Government Decree for consultation,[209] to ensure that the law continues to comply with EU regulations.[210] In August 2021, changes to the EU's General Block Exemption Regulation under which the Finnish Act was governed came into force. Based on the new provisions, 5G networks cannot be subsidised in an area that already has 4G or 5G networks. As a result, the updated program proposed by the Ministry in the amended draft law could no longer support the construction of 5G wireless connections.[211]

The aid-granting process includes a market analysis conducted by Traficom to assess eligible areas. A mapping is carried out to see whether communications networks that meet the minimum speeds required by the regulation are available, and whether construction of a broadband network is planned to over the next three years in the area. The market analysis is to be requested by the provincial association in cooperation with the

[204] Merilampi, 23 January 2020, Finnish Supreme Administrative Court released a SMP-decision concerning wholesale high-quality access at fixed locations – Merilampi represented Elisa. Available at: https://www.merilampi.com/finnish-supreme-administrative-court-repealed-a-smp-decision-concerning-wholesale-high-quality-access-at-fixed-location-merilampi-represented-elisa/

[205] LVM, 2 October 2018, "Digital infrastructure strategy: Turning Finland into the world leader in communications networks." Available (in Finnish) at: https://www.lvm.fi/en/-/digital-infrastructure-strategy-turning-finland-into-the-world-leader-in-communications-networks-985076

[206] Finlex, 30 December 2020, "Law support for broadband connection" 1262/2020. Available (in Finnish) at: https://finlex.fi/fi/laki/alkup/2020/20201262

[207] LVN, 30 December 2020, "Broadband Construction Aid Act enters into force". Available (in Finnish) at: https://www.lvm.fi/-/laajakaistarakentamisen-tukea-koskeva-laki-voimaan-1248896

[208] Traficom, 31 December 2020, "The construction of high-speed network will be supported with EUR 5 million – in the future, holiday homes will also be covered." Available (in Finnish) at: https://www.traficom.fi/fi/ajankohtaista/huippunopeiden-verkkojen-rakentamista-tuetaan-5-miljoonalla-eurolla-jatkossa-myos

[209] Maaseutu.fi, 14 September 2021, "EU-required changes to the Broadband Support Act – opinions requested on draft laws and regulations." Available (in Finnish) at: https://www.maaseutu.fi/laajakaistainfo/uutiset-ja-tiedotteet/laajakaistatukilakiin-eun-edellyttamia-muutoksia-lausuntoja-pyydetaan-laki-ja-asetusluonnoksista

[210] European Commission Regulations (EU) No 651/2016, 17 June 2014: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:02014R0651-20170710&from=FR

[211] Maaseutu.fi, 14 September 2021, "EU-required changes to the Broadband Support Act – opinions requested on draft laws and regulations." Available (in Finnish) at: https://www.maaseutu.fi/laajakaistainfo/uutiset-ja-tiedotteet/laajakaistatukilakiin-eun-edellyttamia-muutoksia-lausuntoja-pyydetaan-laki-ja-asetusluonnoksista

municipalities of the project area. The provincial association is also responsible for declaring the state aid related to the project that can be publicly applied for, and to select the project implementer.

Additionally, Finland has applied for €50 million from the EU Recovery Facility to support broadband, which would complement the national broadband support programme from 2022 onwards.[212]

3.4.3.3 Pro-competition policies

The mobile market is viewed as competitive and to be working effectively to offer mobile consumers choice of prices and quality, with no competition restrictions.[213] There is extensive competition between operators, with heavy marketing of mobile services. However, fixed market competition varies across regional markets and there are provisions to promote competition.

Finland has measures in place on switching and number portability for fixed and mobile services, and Traficom publishes information on how to port numbers and restrictions that might apply on its website. In general, the time to port a number may not exceed 5 days and the maximum time interval between the cessation of old service and the activation of new service is set at 10 minutes for mobile and 60 minutes for fixed services.

3.4.4 Provision and uptake of fixed and mobile services

As outlined in the previous section, the three MNOs/ISPs each offer individual mobile, home internet, fixed telephony and entertainment services. These services are offered separately, though there are some dual-play offers for telecoms and entertainment services. For example, DNA offers a home internet subscription with Netflix add-on, and Telia is currently offering 4G and 5G mobile packages with access to the entertainment platform *C More TV*.

Eurobarometer reports that 79% of households have access to mobile services and fixed internet, and 19% of households have access to these services with fixed telephony.[214] Of the households surveyed, 43% subscribe to a bundled package, which includes mobile services. This has declined by 9% from 2017.

Finland differs from the other FMC case study countries since mobile service is often viewed as substitute to fixed service rather than as a complementary product. Finland has the highest mobile data usage amongst OECD countries (30.99 GB/user/month in 2020). Traficom reports that 47% of data usage in Finland took place over mobile networks in the first half of 2021.[215]

Figure 3.5 shows that 36% of households only subscribe to mobile broadband as the primary home internet service in Finland, the highest in the EU. This is attributed to the comparatively low fixed broadband take-up. Similar fixed-mobile substitution is observed in Italy, Poland and Latvia.[216]

[212] Maaseutu.fi, 14 September 2021, "EU-required changes to the Broadband Support Act – opinions requested on draft laws and regulations." Available (in Finnish) at: https://www.maaseutu.fi/laajakaistainfo/uutiset-ja-tiedotteet/laajakaistatukilakiin-eun-edellyttamia-muutoksia-lausuntoja-pyydetaan-laki-ja-asetusluonnoksista

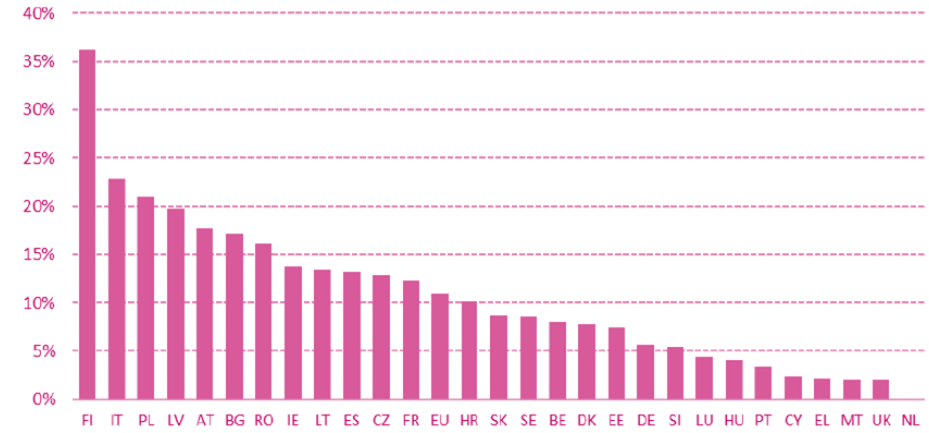
[213] Confirmed to Plum during stakeholder interview with Finnish regulator representative.

[214] Eurobarometer, June 2021, E-Communications in the Single Market. https://europa.eu/eurobarometer/surveys/detail/2232

[215] Traficom, 1 October 2021, Half of the internet usage by Finns travels through the mobile network. Available at: https://www.traficom.fi/en/news/half-internet-usage-finns-travels-through-mobile-network-5g-networks-are-being-built-rapid

[216] European Commission, 2021, Digital Economy and Society Index (DESI) 2020 - Thematic chapters. Available at: https://ec.europa.eu/newsroom/dae/document.cfm?doc_id=67086

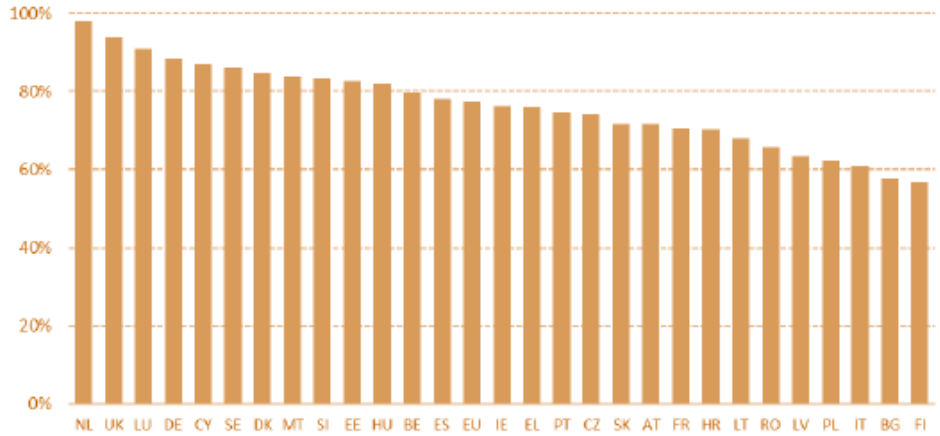
Figure 3.5: Households using only mobile broadband at home (% households), 2019[217]



Source: Eurostat, Community survey on ICT usage in Households and by Individuals.

The take-up of fixed broadband subscriptions in Finland is the lowest amongst all EU countries, less than 60% in 2019. The DESI report also notes a substantial gap between urban and rural fixed broadband penetration rates, with less than half of rural households subscribing to fixed broadband services.

Figure 3.6: Households with a fixed broadband subscription (% of households), 2019



Source: Eurostat, Community survey on ICT usage in Households and by Individuals.

A significant contributor to fixed-mobile substitution is the low NGA coverage, which at 75% of households, is well below the EU average of 86%. Total coverage of very high-capacity networks (VHCN) stood at 58% of households, above the EU average of 44%.[218] This is primarily due to national 4G coverage and increasing coverage of FTTP network; 52.7% of fixed broadband lines are FTTP, above the 19.3% EU average. Finland's 5G readiness, reported as a leader amongst 5G countries,[219] and the main operators' commercial deployment of 5G FWA services are potential drivers of further fixed-to-mobile substitution.

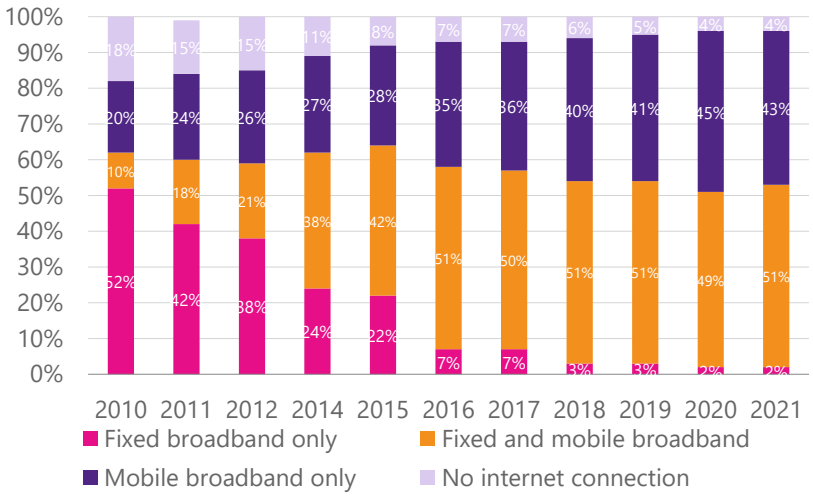
According to the most recent Traficom survey[220] on use of communications services, 53.4% of customers have a fixed internet connection at home, which includes fixed line (wired) and 5G FWA connections. 37.1% of the survey respondents declared that their fixed internet access is provided through their housing company and therefore paid through rent. Regarding wireless LAN (Wi-Fi or mobile hotspot), 77.2% of respondents have one

[217] European Commission, 2021, Digital Economy and Society Index (DESI) 2020 - Thematic chapters. Refer to Figure 32.
[218] European Commission, 2021, DESI Report 2020 – Finland Telecom country chapter2020, Finland country chapter.
[219] European Commission, 2021, Digital Economy and Society Index (DESI) 2020 - Thematic chapters.
[220] Traficom, June 2021, Consumer Survey – Communications services 2021. Available in Finnish at : https://www.traficom.fi/sites/default/files/media/publication/Table-of-results-in-Finnish-2021.ods

at home and only 14.7% have their wireless LAN connected via mobile although 16.7% claimed to be using both mobile and fixed connections.

Strikingly, we observe that the way people access internet at home has changed in the last decade, as shown in Figure 3.7 below. Only 2% of the survey respondents in 2021 use a fixed broadband only connection compared to 52 % in 2010. Conversely the share of customers using mobile broadband only at home has more than doubled in the last 10 years and reached 43% in 2021. However, the majority of people (51%) indicated that both fixed and mobile broadband are used in the household.

Figure 3.7: Type of internet connection used at home, 2021



Note: In this context, mobile broadband refers to either a smartphone Internet connection or a mobile connection acting as a home internet device, e.g., via a 4G modem.
Source: Traficom.

3.4.5 Retail pricing of fixed and mobile services

As noted previously, none of the Finnish operators offer fixed-mobile services within a single package. The three main operators offer both mobile and fixed broadband for home internet access with no data ceiling. Subscriptions are without a fixed term, but a discount for is often proposed to the customers for a certain period if they take up both fixed and mobile services. In some cases, there are discounts to encourage the take-up of additional services (e.g., to encourage mobile take-up from existing fixed subscribers, and vice versa) though these are not widely advertised on the operators' websites.[221]

Whilst the three main operators have a national mobile footprint, they do not have a national fixed footprint. None of the three main operators advertise a standard package or price for fixed (wired) broadband services on their websites.[222] Instead, fixed offers are based on the connectivity available in the subscriber's area[223] and the fixed package price is determined by technology (e.g., fibre, cable, ADSL, VDSL) and connection speeds offered. Potential discounts to encourage take-up of additional services therefore vary across different locations and regions.

[221] From stakeholder discussion, Plum understand that discounts may be directly offered to existing subscribers to encourage uptake of another services. However, existing public information and operator websites provides limited oversight of nature or prevalence of tariff offers and discounts.
[222] Based on Plum survey of main operator websites.
[223] Each of the three main operators require that the exact subscriber address in order to view potential fixed broadband offers.

Consequently, there is insufficient information to directly compare fixed and mobile broadband prices or to assess the impact of discounting to encourage subscribers to take mobile and fixed services from the same operator.

3.4.6 Appraisal

Finland is included as an example of a market with a high level of FMS rather than FMC. A high proportion of households use only mobile broadband at home (36% of households as of 2019) and the share of customers using mobile broadband only at home has more than doubled in the last 10 years, reaching 43% in 2021. Traficom reported that 65% of households had access to fixed broadband connections with a download speed of 100 Mbps or more and 93% of households had access to an equivalent mobile broadband connection. Operators advertise home mobile broadband as a separate service to mobile and fixed broadband, and this is in part driven by popularity of unlimited data mobile offers and a 4G mobile footprint that exceeds that of 100 Mbps capable fixed networks.

There is no regulatory restriction on combining fixed and mobile services in the Finnish market, but network operators have not used fixed-mobile bundling specifically as a strategy to drive take-up or customer retention. Rather, a discounting approach is taken where an operator will provide access to an existing fixed/mobile service at a discount when a new mobile/fixed service is subscribed to. This may in part be due to the market structure in Finland and the presence of more than 20 fixed regional operators (there is no national fixed line incumbent as seen in many other countries).

Hence a combination of factors, including the structure of the fixed operator market and very good mobile connectivity, appear to drive Finland to an FMS rather than FMC position.

3.5 France

Motivation for selection: High uptake of fixed-mobile bundles, and each MNO own (or co-own) some fixed infrastructure with symmetric regulation applying to FTTP networks.

Key market & supply chain features	
Mobile network operators (subscriber share)	Orange (32-37%), SFR (22-27%), Bouygues Telecom (19-24%), Free (17-22%)
Mobile virtual network operators	61 Live MVNOs
Other notable players in broadband supply chain	MNOs operate as fixed service providers.
LTE coverage (% population)	99.0% (Q2 2021)
5G coverage (% population)	19.90% (Q2 2021)
Fast broadband coverage (% households)	62.1% (2020)
Very High Capacity Network (VHCN) coverage (% households)	43.8% (2020)
Mobile data usage (GB/month/sub)	9.7 (2020)
Fixed data usage (GB/month/sub)	142.9 (2020)
Mobile broadband penetration (% population)	161.82 % (Q2 2021)
Fixed broadband penetration (% households)	74% (2020)
Population (million)	67.39 (2020)
Rural population (%)	19%
Households (million)	27.22
Land Area (sq.km)	549,087 (2020)
GDP per capita (US$, current)	38,625 (2020)

Note: Fast broadband (NGA) defined as at least 30 Mbps download. VHCN comprises FTTH, FTTB and Cable Docsis 3.1.
Source: Plum, GSMA Intelligence (2021 Q2), analysis by Opensignal (2021 Q1 values), World Bank (2020 values). OECD (2020 values), European Commission DESI (2020), ITU (2020), Ofcom International Broadband Scorecard (2020).

3.5.1 Market overview

France is a large and developed market, with around 70 million mobile-broadband capable connections. Around 72% of those connections are 4G-capable, and 4G networks have 99% population coverage. In addition, France is now estimated to have around 600,000 active 5G connections.

France also has a developed fixed broadband market. FTTP coverage now exceeds 44% of French households, and 27% have access to DOCSIS 3.0 cable networks.[224] However, while take-up of FTTP services is high among new subscribers, overall France lags far behind the EU average in terms of take-up of >30 Mbps and >100 Mbps services. As of 2019, around 70% of French fixed broadband subscriptions were on a DSL connection.

There are four MNOs active in France:

[224] European Commission, 2021, DESI Report 2020 – France Telecom Chapter. Available at: https://digital-strategy.ec.europa.eu/en/library/2020-desi-report-electronic-communications-markets-overview-member-state-telecom-chapters

- **Orange S.A.** was formed following a merger with former incumbent France Télécom. It has a 32-37% share of mobile connections.[225] As the former incumbent, Orange operates the legacy copper network, but it has also been deploying FTTP for a number of years – in 2021 it reported 5.3m FTTH customers in France.[226] Orange estimated it had a 40% market share of the fixed market in 2017.[227]

- **Altice-SFR** has a 22-27% share of mobile connections.[228] It operates a cable network with a footprint of around 40% of the population. It also has a FTTP network covering 2.8m homes in France. In addition, its subsidiary, SFR FTTH, is an infrastructure wholesaler with a planned FTTP footprint of 5.4m homes.[229] According to its 2019 annual report, Altice France had around 7.2m fixed subscribers.[230]

- **Bouygues Telecom** has a 19-24% share of mobile.[231] In 2020 Bouygues Telecom formed a joint venture with Cellnex Telecom to deploy a national fibre optic network, with the intention of supporting 5G in France.[232] It also formed a joint venture with Vauban Infrastructure Partners to deploy FTTH networks to 'medium density' areas, building on previous joint investment.[233] In 2021 Bouygues reported a total of 4.3m fixed broadband customers, of which 1.9m are FTTP customers.

- **Free Mobile** (Iliad) has a 17-22% share of mobile connections.[234] It also operates a fixed backbone network, providing fixed broadband services to customers via unbundled local loops. However, it has also been deploying a FTTP network and, as of 2021, reported 3.3m FTTP customers.[235]

Since the entry of Free Mobile, the mobile subscriber shares of the four mobile operators have been relatively stable. From 2015, the shares of Altice-SFR and Bouygues Telecom have experienced a gradual increase, largely at the expense of Orange. In addition to the four MNOs, there are 61 MVNOs currently active in France.[236] The majority of these MVNOs are hosted on Orange or SFR.

3.5.2 Changes in market structure – FMC mergers

Since Free Mobile (Iliad) entered the French mobile market in 2009, there has been relatively little change in the French mobile market. In 2016 it was reported that Bouygues and Orange were in discussion to merge, though the proposal ultimately fell through.[237]

In the fixed market, a key recent development is the acquisition of wholesale-only fibre network operator, Covage, by Altice/SFR in December 2020. Covage provided FTTP and fibre-to-the-office (FTTO) services and was particularly active in lower density areas.

[225] Source: GSMA Intelligence, 2021. Number of connections refers to network connections (including hosted MVNO subscribers). Mobile connections refer to mobile services with or without data packages (i.e., including mobile broadband subscriptions).
[226] Orange, 2021, Orange financial results H1 2021 presentation. Available at: https://www.orange.com/sites/orangecom/files/2021-07/H1%2021%20Presentation%20-%20EN%20-%20v%20def.pdf
[227] SEC filing, 2017. https://www.sec.gov/Archives/edgar/data/1038143/000163462118000014/exhibit_15.1.htm
[228] Source: GSMA Intelligence, 2021. Number of connections refers to network connections.
[229] Altice, 2020, Altice Europe N.V. Annual Report 2019. Available at: https://altice.net/sites/default/files/pdf/Altice%20-%20Annual%20report%202019%20-%20vf2.pdf
[230] Based on Plum analysis.
[231] Source: GSMA Intelligence, 2021. Number of connections refers to network connections.
[232] Light Reading, 26 February 2020, Cellnex and Bouygues Telecom seal fiber deal to support 5G. Available at: https://www.lightreading.com/5g/cellnex-and-bouygues-telecom-seal-fiber-deal-to-support-5g/d/d-id/757783
[233] Natixis, 17 July 2020, Vauban Teams up with Bouygues Telecom for Fibre Network Investment in Dense and Mid Dense Areas in France. Available at: https://www.im.natixis.com/en-institutional/news/news/vauban-teams-up-with-bouygues-telecom-for-fibre-network-investment-in-dense-and-mid-dense-areas-in-france
[234] Source: GSMA Intelligence, 2021. Number of connections refers to network connections.
[235] Iliad Group, 5 August 2021, Analysis of the Groups Business and Results. Available at: https://iliad-strapi.s3.fr-par.scw.cloud/Rapport_Gestion_S1_2021_050821_Eng_8b8166098f.pdf
[236] Source: GSMA Intelligence, 2021.
[237] BBC, 5 January 2016, French telecom firms Orange and Bouygues in merger talks. Available at: https://www.bbc.co.uk/news/business-35230852

In November 2020, the European Commission raised serious competition concerns about the merger.[238] These included the loss of competitive constraint in the wholesale FTTO market and the risk of foreclosure of other access seekers by the merged entity.

Altice/SFR offered two commitments to allay the European Commission's concerns. Firstly, it would divest a number of subsidiaries and assets, collectively representing around 95% of Covage's FTTO business. Second, it would offer a transitional business agreement to allow the divested businesses access to the necessary assets and services. The Commission approved the merger subject to compliance with these commitments.

3.5.3 Policy and regulatory environment

3.5.3.1 Fixed access regulation

There are two aspects to French fibre access regulation. Firstly, "asymmetric" regulation for the following markets.

- Physical infrastructure;
- Wholesale local access provided at a fixed location;
- Wholesale central access provided at a fixed location for mass-market product; and
- High-quality dedicated active solutions for businesses.

ARCEP noted that, in 2020, Orange controlled 99.99% of copper accesses and (directly or via a Public Initiative Network) 69% of FTTP accesses.[239] Orange's wholesale market share (excluding self-supply) of fibre is 67%. ARCEP proposed to designate Orange as the operator with significant market power (SMP) in each of the notified markets and imposed a range of regulatory obligations, including access, non-discrimination and price controls.

The other aspect to fibre access regulation is "symmetric" regulation, which sets up passive access to terminating segments of FTTP networks. The rules require all operators installing FTTP in buildings to deploy it in such a way as to allow access to be provided to passive (dark fibre) at concentration points aggregating at least 1,000 lines.[240] Offers must include the potential for co-financing (on the basis of indefeasible right of use or IRU) before the investment occurs, after the investment – or on the basis of short term rental. The terms and conditions as well as prices were set in practice through a series of disputes resolved by the regulator in 2011. Prices were cost-based, but with mark-ups on the WACC to account for increased risk.[241]

3.5.3.2 Initiatives for NGA provision

The objective of the "France Very High Broadband Plan" ("France Très Haut Débit") is to cover the whole population by giving households, enterprises and administrations access to very high-speed broadband services

[238] European Commission, 27 November 2020, Mergers: Commission clears Altice, Allianz and Omers' joint acquisition of Covage, subject to conditions. Available at: https://ec.europa.eu/commission/presscorner/detail/eS/ip_20_2238
[239] Letter from European Commission to ARCEP, 26 November 2020. Available at: https://circabc.europa.eu/sd/a/d4cff090-81cd-435b-8df3-8291f4042f01/FR-2020-2277-2278-2279-2280%2520Adopted_EN_Redacted.pdf
[240] This does not apply to very dense areas, where only access to in-building wiring is shared.
[241] WIK-Consult, 26 February 2019, Prospective competition and deregulations: An analysis of European approaches to regulating full fibre. Available at: https://www.ofcom.org.uk/__data/assets/pdf_file/0020/145046/b-group-wik-report-annex.pdf

by 2022, through complementary public and private initiatives. A €20 billion investment over 10 years is shared among local government, the central State and private operators in order to cover both rural and urban areas.

- Rural areas – representing 45% of population – are being covered by Public Initiative Networks ("Réseaux d'Initiatives Publiques") that are owned by local authorities[242] and with services provided by Internet providers to individuals and enterprises, through different technologies (FTTP, ADSL improvement, satellite, WiMax, 4G). In order to cover these areas, funding of the programme's €13-14 billion investment is shared equally between public authorities and commercial players: €6.5 billion is funded by public subsidies (including €3.3 billion from the central State) and the other half is funded by operating revenues from Internet providers.

- Very high-speed broadband in urban areas – 55% of population – is deployed and funded by private operators (€6-7 billion).

In order to guarantee the proper functioning of the internet in France, ARCEP has switched its evaluation method of internet access QoS by making crowdsourced information,[243] which is readily available to internet users.

In January 2018, the French government announced an agreement[244] with MNOs, which seeks to ensure the availability of high-standard mobile coverage for every person in the country. Acting on a proposal from ARCEP, the Government made regional coverage consistency a priority in its frequency assignment policy.

The new deal for mobile aimed to achieve large 4G coverage across Metropolitan France, introduce a targeted scheme designed to improve coverage significantly in specific areas. The new obligations, including a requirement to ensure the coverage of 5,000 new locations were included in the licences to make the operators' commitments legally binding.

In the 3.4-3.8 GHz band 90 MHz is set aside for fixed wireless access (FWA) until 2026. The remainder of the band was awarded in late 2020.

The award of this spectrum was accompanied by a set of obligations on the successful candidates, including:

- that each operator must launch 5G services in at least two cities before the end of 2020, and deploy a certain number of sites by 2025;

- that by 2022, at least 75% of cell sites must be capable of providing speeds of at least 240 Mbps at each site; and

- that by 2027, 55,000km of the country's roads must be covered by 5G.[245]

Candidates that made an optional, additional series of commitments in their application were awarded 50 MHz of the spectrum. These commitments involved improving indoor coverage, the supply of dedicated fixed access products on mobile networks, and commitments to granting reasonable requests for 'customised solutions' in terms of coverage and performance. The four mobile network operators made the additional commitments and were each awarded 50 MHz.

[242] Local governments ("Collectivités Territoriales")
[243] Stakeholders include QoS measurement service providers, operators, consumer associations, etc.
[244] ARCEP, 10 November 2020, "New Deal for Mobile": 4G for everyone in France. Available at: https://en.arcep.fr/news/press-releases/view/n/new-deal-for-mobile-4g-for-everyone-in-france-101120.html
[245] The commitments are set out on ARCEP's website. ARCEP, 31 December 2019, 5G: https://en.arcep.fr/news/press-releases/view/n/5g-23.html

The remaining 110 MHz was then auctioned in 10 MHz blocks. This spectrum was also awarded to the mobile network operators.[246]

3.5.3.3 Pro-competition policies

ARCEP has undertaken a number of initiatives to help consumers make an informed choice. For instance, it has introduced user tutorials for transferring data between phones.[247] ARCEP regularly publishes information on mobile quality of service and on the state of French internet services.

In terms of fixed networks, ARCEP has, in collaboration with stakeholders, developed and published a code of conduct to encourage the players involved in testing QoS to guarantee a minimum level of transparency and robustness. Five entities involved in QoS testing have declared themselves compliant with the code of conduct. A new version of the code was published in 2020.[248]

The OECD has noted that ARCEP has plans to provide users with precise and personalised information by both 'crowd-sourcing' information and application programming interfaces implemented in operators' set-top boxes to measure quality of the networks more accurately. [249]

In 2017, the head of ARCEP aired concerns about French telecom operators investing heavily in content. The concerns centered around the risks that a content-heavy strategy would deter investment in networks – particularly fibre and 4G/5G.[250] Convergence between telecoms and media is a growing trend in the market – a trend that is led in particular by SFR, which has a range of sports and content rights.[251] In spite of this, there appears to be no restrictions on bundling services in France, and operators offer triple- and quad-play bundles.

3.5.4 Provision and uptake of FMC bundles

The most recent communications market report from regulator ARCEP indicates that, as of March 2021, 30% of France's 70 million post-paid SIM cards are coupled with fixed access (note that several SIM cards can be paired with the one fixed internet subscription).[252] ARCEP notes that this proportion has changed little over the past five years. ARCEP reported in 2017 that there were over 19 million subscriptions to fixed-mobile bundles.[253]

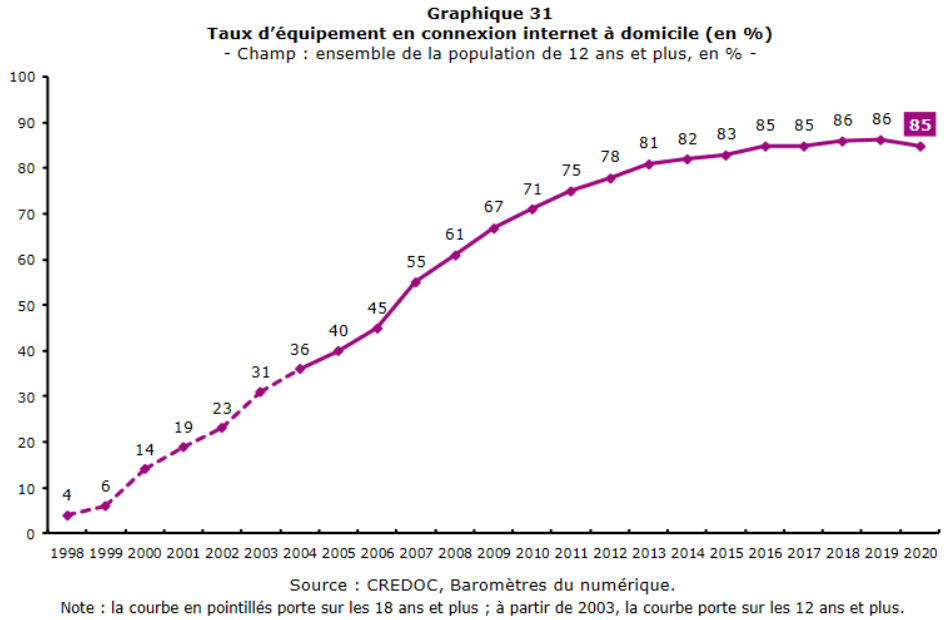
The market report also notes that, of 31 million active internet subscriptions, 73% (22.5 million) had an audio-visual service bundle. This proportion is also relatively steady over time.

According to the 2021 Eurobarometer survey, 13% of French households do not subscribe to a fixed internet service. 7% of households rely on mobile only – i.e. they do not have fixed internet or fixed telephone connections.[254] Data from the telecoms regulator, ARCEP, suggests that 15% of the population does not have a

[246] ARCEP, 1 October 2020, 5G: Auction for the award of 3.4 – 3.8 GHz band spectrum is closed. Available at: https://en.arcep.fr/news/press-releases/view/n/5g-011020.html
[247] ARCEP, 14 November 2018, Net neutrality – Consumers – Take back control of your smartphone: Arcep publishes user tutorials. Available at: https://en.arcep.fr/news/press-releases/view/n/consumers.html
[248] ARCEP, 14 September 2020, 2020 code of conduct on Internet quality of service. Available at: https://www.arcep.fr/uploads/tx_gspublication/code-of-conduct-QoS-Internet-2020_EN_sept2020.pdf
[249] OECD, 2020, Digital Economy Outlook 2020.
[250] Financial Times, 29 January 2017, French mobile groups' bundling trend risks harm, watchdog warns. Available at: https://www.ft.com/content/f962668e-df32-11e6-86ac-f253db7791c6
[251] See for example https://www.globenewswire.com/en/news-release/2017/07/27/1063777/0/en/SFR-Group-Q2-2017-Results.html
[252] ARCEP, 1 July 2021, Marché des communications électroniques en France - Les chiffres au 1er trimestre 2021. Available (in French) at: https://www.arcep.fr/cartes-et-donnees/nos-publications-chiffrees/observatoire-des-marches-des-communications-electroniques-en-france/marche-des-communications-electroniques-en-france-les-chiffres-au-1er-trimestre-2021.html
[253] ARCEP Press Release, 19 May 2017, Arcep published key economic indicators. Available at: https://en.arcep.fr/news/press-releases/view/n/arcep-publishes-key-economic-indicators.html
[254] European Commission, June 2021, E-Communications in the Single Market. Eurobarometer. https://europa.eu/eurobarometer/surveys/detail/2232

fixed internet connection at home, and that this figure has been constant over the past five years.[255] Of these non-users, 14% say that a mobile internet connection is sufficient for them.

Figure 3.8: Home internet connections, % households 1998-2020



The same Eurobarometer survey indicates that in 2021, 37% of French households bought mobile services as part of a bundle, a decline of five percentage points from the previous survey in 2017.[256] The same survey finds that 49% of French households bought fixed internet access as part of a bundle, also a decline of five percentage points from 2017. One potential factor behind this decline may be strong price competition in the French mobile market, which may encourage users to buy mobile services separately.[257]

3.5.5 Retail pricing of FMC bundles

At the time of writing:

- Orange offers a fibre broadband, fixed telephony, TV and mobile bundle for an introductory monthly price of €29.99 (12-month contract), with a price of €63.99 out of offer. The price for the corresponding standalone mobile package is €19.99/€34.99 (offer/no offer). The price for the corresponding fibre broadband, fixed telephony, and TV bundle package is €22.99/€41.99 (offer/no offer).[258]

- SFR offers a fibre broadband fixed telephony, TV and mobile bundle for an introductory monthly price of €20 (12 month contract), with a price of €63 out of offer. The price for the corresponding mobile package is €20/€35 (offer/no offer). The price for the corresponding fibre broadband, fixed telephony, and TV bundle package is €10/€38 (offer/no offer).[259]

- Bouygues offers a fibre broadband fixed telephony, TV and mobile bundle for an introductory monthly price of €21.98 (12-month contract), with a price of €56.98 out of offer. The price for the corresponding

[255] ARCEP, 2021, Baromètre du Numérique Edition 2021. Available (in French) at: https://www.arcep.fr/uploads/tx_gspublication/rapport-barometre-numerique-edition-2021.pdf
[256] European Commission, June 2021, E-Communications in the Single Market. Eurobarometer.
[257] Nicolle, Grzybowski and Zulehner, 8 November 2019, Impact of competition, investment and regulation on prices of mobile services: evidence from France. Available at: https://hal.archives-ouvertes.fr/hal-02102353v2/document
[258] Refer to https://www.orange.fr/portail Prices assessed September 2021.
[259] Refer to https://www.bouyguestelecom.fr/ Prices assessed September 2021.

mobile package is €16.99/€31.99 (offer/no offer). The price for the corresponding fibre broadband and fixed telephony package is €9.99/€29.99 (offer/no offer).[260]

- Free Mobile offers a fibre broadband fixed telephony, TV and mobile bundle for an introductory monthly price of €39.98 (12 month contract), with a price of €49.98 out of offer. The price for the corresponding mobile package is €19.99. The price for the corresponding fibre broadband package is €29.99/€39.99 (offer/no offer).[261]

All operators offer fixed-mobile bundles at significant discount (typically around 20%) compared to buying the same fixed and mobile connectivity separately. The discount is often explicitly advertised on the operators' websites.

3.5.6 Appraisal

The most recent Eurobarometer survey indicates that in 2021, 37% of French households bought mobile services as part of a bundle. While bundles tend to offer significant discounts, there is some evidence to suggest that the proportion taking bundles has fallen in recent years, although the overall proportion is above the EU average. However, the commitments on mobile operators to provide 5G services (and fixed wireless access services on mobile networks) may help create more effective substitutes for wireline connectivity.

All four of the country's mobile network operators also own (or co-own) fibre infrastructure. Each reports significant numbers of fixed broadband and FTTP subscribers. In addition, the symmetric regulation on operators of FTTP networks means that access must be granted on a non-discriminatory basis. Whilst Orange operates the most extensive fibre network (as well as the legacy copper network), it is also subject to asymmetric' regulation requiring it to provide access at regulated prices.

In practice a mobile operator would therefore be able to offer fixed connectivity through 1) its own infrastructure, 2) purchasing infrastructure from a FTTP network operator (including wholesale and Public Initiative Networks), or 3) wholesale products from Orange. Operating the most extensive fixed network does not appear to have given Orange a commercial advantage in the mobile market, where its market share has experienced a gradual but steady decline over the past ten years.

[260] Refer to https://mobile.free.fr/ Prices assessed September 2021.
[261] Refer to https://www.sfr.fr/ Prices assessed September 2021.

3.6 Netherlands

Motivation for selection: Fixed-mobile and pay-TV bundles as a consequence of numerous mergers between mobile, fixed and cable players.

Key market & supply chain features	
Mobile network operators (subscriber share)	KPN (43-48%), T-Mobile 25-30%), Vodafone-Ziggo (22-28%) (2021 Q2)
Mobile virtual network operators	53 MVNOs and resellers accounting for approx. 40% connections. Main MVNOs: Simpel, Lebara, Lycamobile.
Other notable players in broadband supply chain	All MNOs own fixed infrastructure, offering both retail and wholesale access. There are also some small regional fixed broadband suppliers.
LTE coverage (% population)	99.5% (2021 Q2)
5G coverage (% population)	56.2% (2021 Q2)
Fast broadband coverage (% households)	98% (2020)
Very High Capacity Network (VHCN) coverage (% households)	89% (2020)
Mobile data usage (GB/month/sub)	3.71 (2020)
Fixed data usage (GB/month/sub)	119.0 (2020)
Mobile broadband penetration (% population)	110.41% (2021 Q2)
Fixed broadband penetration (% households)	103% (2020)
Population (million)	17.44
Rural population (%)	7.7%
Households (million)	7.33
Land Area (sq.km)	33,670 (2020)
GDP per capita (US$, current)	52,304 (2020)

Note: Fast broadband (NGA) defined as at least 30 Mbps download. VHCN comprises FTTH, FTTB and Cable Docsis 3.1.
Source: Plum, GSMA Intelligence (2021 Q2), analysis by Opensignal (2021 Q1 values), World Bank (2020 values). OECD (2020 values), European Commission DESI (2020), ITU (2020), Ofcom International Broadband Scorecard (2020).

3.6.1 Market overview

The Netherlands has a highly-developed telecoms market, with high uptake of fixed telephony (97% of households), mobile telephony (98% of households) and fixed internet access (99% of households).[262] Bundling is common: 86% of households purchase fixed broadband as part of a bundle.[263]

Fast broadband (NGA) coverage is above the EU average, covering 98% of households nationally and 96% in rural areas. Four out of five Dutch homes have access to FTTP or FTTC services from KPN's fixed network, and

[262] European Commission, June 2021. E-Communications in the Single Market. Special Eurobarometer 510. Available at https://europa.eu/eurobarometer/surveys/detail/2232
[263] European Commission, June 2021. E-Communications in the Single Market. Special Eurobarometer 510.

upgrade of cable networks to DOCSIS 3.1 has helped increase very high capacity network (VHCN) coverage to 89% in 2019.[264,265] In addition there is 99.5% population coverage of 4G services, as of 2021 Q2.[266]

The Netherlands has a competitive mobile market with three MNOs and a strong MVNO presence. All three MNOs have fixed operations allowing them to provide bundled or standalone fixed broadband and telephony services, as discussed below.

- **KPN** is the incumbent operator offering fixed network and mobile services. It offers (fixed) Internet, TV subscription and mobile as individual or bundled services (an unbundled KPN TV subscription is not available). As of 2021 Q2, KPN is the largest mobile operator with 9.5 million subscribers. KPN also has 3.1 million residential broadband subscribers at end-2020. It has a ubiquitous national fixed network and offers wholesale fixed and mobile interconnection to other telecom service providers (similar to BT Openreach). KPN is currently upgrading its network to be fibre-based, with target of connections 40% of Dutch households with a full fibre connection by end-2020.[267,268]

- **T-Mobile** is the second largest mobile operator, with 5.6 million mobile connections (2021 Q2). T-Mobile offers mobile, fixed broadband, fixed voice and TV subscription services as individual and bundled services as T-Mobile and sub-brand Tele2. In 2018, T-Mobile NL and mobile-fixed operator Tele2 NL announced a merger.[269] At the time, T-Mobile was 2G and 3G-only mobile operator and Tele2 was operating as a 4G-only MNO, as well as fixed broadband services to residential and business customers. The merger was completed in January 2019, with the legal entity Tele2 NL being merged into parent company T-Mobile NL to further simplify the legal structure of the merger.[270] Prior to T-Mobile-Tele2 merger, in late 2016, T-Mobile acquired Vodafone Thuis' (rebranded as *T-Mobile Thuis*) – 150,000 fixed-line business customers which were divested as part of the Vodafone-Ziggo merger conditions.[271]

- **Vodafone-Ziggo** is the third largest mobile operator, with 5.3 million mobile connections (2021 Q2), and the largest fixed operator, with 3.4 million fixed broadband subscribers (end 2020). The companies merged in 2016. Prior to this merger, Ziggo (owned by Liberty Global) specialised in pay TV[272] and fibre broadband services with a small mobile subscriber base, and Vodafone was a mobile operator providing some fixed broadband and telephony services to business segment. In approving the Vodafone-Ziggo merger, the European Commission's investigation concluded that the Dutch mobile market was highly competitive with some of the lowest mobile prices in the EU and high network quality.

There are over 50 active MVNOs and MNO sub-brands which collectively represented nearly 3.6 million SIMs (or 17% of all SIMs) by end September 2020 and primarily target the low-cost, "no frills" segment.[273] The MVNO market share was reported to be approximately 35% of the domestic mobile market in 2012 Q1.[274] However this

[264] KPN, 2021, Fixed network – Modern for more than a century. Available at: https://www.overons.kpn/en/kpn-in-the-netherlands/our-network/fixed-network

[265] European Commission, 2021, DESI Report 2020 – Netherlands Telecom Chapter. Available at: https://digital-strategy.ec.europa.eu/en/library/2020-desi-report-electronic-communications-markets-overview-member-state-telecom-chapters

[266] Source for all MNOs mobile connections and market share from GSMA Intelligence database, 2021.

[267] KPN, 2021, Fixed network – Modern for more than a century. Available at: https://www.overons.kpn/en/kpn-in-the-netherlands/our-network/fixed-network

[268] KPN's current network upgrade is based on FTTC with VDSL from street cabinet to property.

[269] European Commission, 27 November 2018, Mergers: Commission clears T-Mobile NL's acquisition of Tele2 NL. Available at: https://ec.europa.eu/commission/presscorner/detail/en/IP_18_6588

[270] Telegeography, 18 December 2019, T-Mobile Netherlands simplifying legal structure in January. Available at: https://www.commsupdate.com/articles/2019/12/18/t-mobile-netherlands-simplifying-legal-structure-in-january/

[271] tweakers, 3 August 2016, "European Commission approves merger Vodafone and Ziggo subject to conditions." Available (in Dutch) at: https://tweakers.net/nieuws/114253/europese-commissie-keurt-fusie-vodafone-en-ziggo-goed-onder-voorwaarden.html

[272] Ziggo NL merged with UK-based Liberty Global in 2014. At the time, both offered cable TV services in the Netherlands and Ziggo provided broadband internet services over its cable network. In 2016, Ziggo became part of the newly formed joint venture Vodafone-Ziggo, in which Liberty Global is a partner.

[273] Source: GSMA Intelligence data, 2021, and Telecompaper, 31 December 2021, MVNOs outperform Dutch mobile market growth, reach 17% of Sims. Available at: https://www.telecompaper.com/news/mvnos-outperform-dutch-mobile-market-growth-reach-17-share-of-sims--1367224

[274] Telegeography. 7 August 2012, MVNOs increase Dutch market share to 35.9%, paper says. Available at: https://www.commsupdate.com/articles/2012/08/07/mvnos-increase-dutch-market-share-to-35-9-paper-says/

has decreased in response to competition from MNOs' bundled offers and a number of MVNOs' acquisitions made by MNOs, including T-Mobile's acquisition of the largest MVNO Simpel in 2020.[275,276]

The Netherlands fixed broadband market is reasonably concentrated with Ziggo and KPN accounting for over 80% of the market at end-2020; the operators had 3.4 million and 3.1 million subscribers respectively. Since its 2016 merger with Tele2, T-Mobile has achieved a strong growth in fixed broadband subscribers, with 668,000 subscribers reported by end-2020. The number of KPN subscribers has steadily fallen since 2018 following the decision to phase out its second brands, despite the rollout of FTTP network. Analysis from Telecompaper indicates that both Ziggo and KPN have relied on bundling fixed and mobile services with discounts and other products (e.g., TV platforms) to grow their subscriber base. By the end of 2020, KPN's FMC contracts surpassed 50% of all broadband subscribers, while and Ziggo's FMC contracts represented over 43% of broadband contracts.

There are also a number of smaller local networks and local fibre co-operations providing regional and rural coverage. For example, Online.nl (a cable operator offering fibre and cable broadband services as part of T-Mobile NL parent company holdings but functionally separate form main T-Mobile operation), DELTA and Caiway (cable and fibre operators offering TV, internet and telephony services, brands of regional-fibre operator DELTA Fiber Netherlands)[277] and youfone, which offers mobile, TV and fixed broadband based on access to KPN's fibre and 4G networks).

3.6.2 Changes in market structure – FMC mergers

The high level of fixed-mobile convergence in the Netherland's mobile market has resulted from cable operators and incumbent fixed line operators expanding their service offer to add-on telecom and IPTV services in the 2000s. This was in response to growing competition from cable operators, who had traditionally offered television services, launching add-on broadband or telephony services.

A report published in 2007 by the Dutch Independent Post and Telecommunications Authority (OPTA), the predecessor of the Authority for Consumer & Markets (ACM), noted that the Netherlands was seeing early stages of (non-symmetric) convergence, as households increasingly opted to receive all their fixed communications services from a single provider.[278] At the time, KPN offered fixed telephony and broadband and had recently launched its own television service

The trend towards FMC and bundled products has been exacerbated by several mergers in the last 20 years. Significant market mergers include:

- KPN's acquisition of the mobile brand Telfort in July 2005. Telfort initially launch in 1997 as a joint venture between BT and Dutch Railways. BT became the sole owner in 2000, rebranding Telfort to O2. However, in 2003, O2 was sold to Greenfield Capital Partners who reverted back to the use of the Telfort brand name and eventually sold Telfort in 2005 to KPN. In 2007, KPN then bought the Dutch operators of Tiscali, rebranding its internet services as Telfort Internet. Telfort/Telfort Internet subsequently expanded its service offering to include fixed telephony and IPTV subscriptions. In 2018, Telfort was subsumed into the KPN brand name and ceased to exist as a separate legal identity.

[275] For example, T-Mobile agreeing to buy MVNO Simpel, reported on 9 October 2020. https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/t-mobile-netherlands-agrees-to-buy-mvno-simpel-8211-telecompaper-60788267
[276] Telecompaper, 15 July 2021, MVNOs down to 12.5% of Dutch mobile market but still growing in no=-frills segment. Available at: https://www.telecompaper.com/news/mvnos-down-to-125-of-dutch-mobile-market-but-still-growing-in-no-frills-segment--1390209
[277] DELTA Fiber Netherlands, 2021. Available at: https://www.deltafibernederland.nl/en/about-us/delta-fiber-netherlands/
[278] OPTA, August 2007, The Bundle the Market? Regulatory Policy Note No.5. Available a: https://www.acm.nl/sites/default/files/old_publication/publicaties/9379_The%20Bundle%20The%20Market%20-%20Regulatory%20Position%20Note%20nr.%205.pdf

- T-Mobile NL's acquisition of mobile operator Orange NL from France Telecom in 2007. The acquisition was approved by the European Commission on the basis that it would not materially alter or impede the domestic mobile market.[279] As a result of the acquisition, T-Mobile's mobile market share increased from 15% to more than 27%, which equated to an additional 612,000 fixed internet users.[280]

- Merger of Ziggo NL and Liberty Global's Dutch unit UPN in 2014. At the time, the competing operators both had regional cable networks offering IPTV and broadband services. The Commission cleared the merger subject to conditions.[281,282] Ziggo and UPC tried to launch a mobile brand, ZUM, which, however, failed to acquire any spectrum in the 2012 4G auction (instead Tele2 secured the 800 MHz allocation reserved for a new entrant) and ended up offering limited mobile broadband-only services using 2.6 GHz holding.[283]

- Vodafone-Ziggo merged in 2016 through a 50:50 joint venture arrangement. At this time, Ziggo was offered a national broadband network (upgrading parts of its cable network to fibre) and an extensive Wi-Fi network along with its IPTV offering. Vodafone was the leading mobile operator with a nationwide 4G network. It also provided B2B services through its *Vodafone Thuis* business unit; though this had to be sold as a condition of the merger and was bought by T-Mobile.

- T-Mobile NL and Tele2 NL announced a merger in December 2017, which was approved by the European Commission without conditions. Tele2 offered fixed broadband and telephony, data network and content services. Tele2 was operating as an MVNO using T-Mobile's network before launching 4G mobile services using its own 800 MHz and 2.6 GHz spectrum holdings.[284] The merger was completed in 2019, and the legal structure was simplified in 2020.

3.6.3 Policy and regulatory environment

In the Netherlands, the responsible government department is the Ministry of Economic Affairs and Climate policy, and the ACM is the regulator of the communications market. Their responsibilities accord with the following acts:

- *Dutch Telecommunications Act* (June 2012),[285] which states the regulator (now ACM) is responsible for registration of network and service providers, numbering (including allocation), regulating market competition and obligations of undertakings with SMP, obligations relating to access, and dispute resolution responsibilities amongst other provisions. The Act state the communication sector regulator's objectives as:

[279] European Commission, 20 August 2007, Case No COMP/M.4748 T-MOBILE/ORANGE NETHERLANDS. Regulation (EC) No 139/2004 Merger Procedure. Available at: https://ec.europa.eu/competition/mergers/cases/decisions/m4748_20070820_20310_en.pdf

[280] Telegeography. 21 August 2007, EU approves Orange NL takeover by T-Mobile. Available at: https://www.commsupdate.com/articles/2007/08/21/eu-approves-orange-nl-takeover-by-t-mobile/

[281] The merger conditions required Liberty Global to remove clauses that would restrict broadcasters' ability to offer channels and content over the internet, maintain access to its network and not repurchase pay TV operator Film1. https://www.libertyglobal.com/european-commission-approves-liberty-globals-2014-purchase-of-ziggo/

[282] In October 2017, the European General Court annulled the Commissions 2014 decision to approve the acquisition for reasons relating to the original review's market definition. Subsequently the Commission were required to reinvestigate the acquisition in view of the General Court's judgement and in view of current competition conditions. In 2021, the acquisition was reapproved, and the general court dismissed KPN's complaint. Sources: https://www.concurrences.com/IMG/pdf/t_691_18_en.pdf?65900/bd00f452393e6da27c576632dcea2939a5133efa , https://globalcompetitionreview.com/behavioural-remedies/general-court-backs-eu-enforcer-in-liberty-globalziggo-challenge

[283] Telecoms.com, 20 December 2012, The Dutch 4G Auction and the Law of Unintended Consequences. Available e at: https://telecoms.com/opinion/the-dutch-4g-auction-and-the-law-of-unintended-consequences/

[284] Telecoms.com, 20 December 2012, The Dutch 4G Auction and the Law of Unintended Consequences.

[285] Government NL, 27 August 2012, Dutch Telecommunications Act – translation of 'Telecommunicatiewet – Juni 2012'. Available at: https://www.government.nl/documents/policy-notes/2012/06/07/dutch-telecommunications-act

  - promotion of competition in provision of electronic communications networks, electronic communication services, or associated facilities, including by encouraging efficient investment in the field of infrastructure and supporting innovation;
  - the development of the internal market; and
  - promotion of end-user interests as regards to choice, price, and quality.

  The Act sets out that the Ministry is responsible for spectrum management and frequency assignment (including competitive awards). The Act also notes provisions for other stakeholders, for example local municipalities and communication network providers, in the rollout of fixed services.

- *Establishment Act of the Authority for Consumers and Markets* (February 2013),[286] which established the ACM as the sector regulator and outlines its responsibilities and obligations. This replaces the *Independent Post and Telecommunications Authority Act*.

- *Dutch Competition Act* (1997) outlines the responsibilities and powers of the competition regulator, also the ACM.

3.6.3.1 Fixed access regulation

As part of its regulatory oversight, the ACM conducts regular market reviews of both the fixed and mobile markets. Local access to copper and FTTH are regulated and FTTO (business-grade FTTP) and coaxial networks are unregulated.[287]

In 2018, the ACM published a decision on Wholesale Fixed Access (WFA) that both KPN and Vodafone-Ziggo should open up their fixed networks to other providers.[288] Prior to this decision, the ACM had required KPN to provide competitors access to its network – a decision that was reaffirmed in 2014.[289] Following the joint venture of Vodafone and Ziggo in 2016, the competitive landscape became more symmetric (both Vodafone-Ziggo and KPN have fixed and mobile operations) leading the ACM to undertake a further market analysis. In its 2018 market analysis, the ACM decided that both KPN and Vodafone-Ziggo have joint SMP in both the wholesale local access and wholesale central access at a fixed location for mass-market products. The regulatory decision came into effect in October 2018, with justification that their strong market positions could allow them to raise access prices, adjust conditions to their advantage or delay investments.[290] The decision, however, was overturned in 2020 by the Dutch Trade and Industry Appeals Tribunal (CBb), the highest administrative-law court in the Netherlands.

In May 2020, the Dutch House of Representatives granted additional powers to the ACM through an amendment of the *Dutch Telecommunications Act*. The amendment granted more powers to protect

[286] ACM, 28 February 2013, Establishment Act of the Authority for Consumers and Markets. Available at: https://www.acm.nl/sites/default/files/old_publication/publicaties/13190_establishment-act-of-the-netherlands-authority-for-consumers-and-markets.pdf

[287] ACM, 7 March 2012, Commercial wholesale agreements in the Netherlands – presentation for WIK Investment Workshop, Brussels. Available at: https://wik.org/fileadmin/Konferenzbeitraege/2017/Interactive_Workshop/Presentation_Johan_Keetelaar__Director_ACM__for_the_WIK_Investment_Works....pdf

[288] The preliminary comments from the European Commission did not disagree with the ACM's findings of joint-SMP in WFA market. The Commission did, however, ask the regulator to further substantiate its conclusions regarding market definition and to monitor whether local access products and central access products continued to be functional substitutes. More information is available from the Commission: https://digital-strategy.ec.europa.eu/en/news/commission-issues-comments-proposed-regulation-wholesale-internet-access-market-netherlands

[289] ACM, 31 October 2014, For the next three years Dutch telecom company KPN must continue to grant its competitors access to its network. Available at: https://www.acm.nl/en/publications/publication/13464/For-the-next-three-years-Dutch-telecom-company-KPN-must-continue-to-grant-its-competitors-access-to-its-network

[290] ACM, 17 March 2020, Highest administrative-law court in the Netherlands has reversed ACM's decision to open up the networks of KPN and VodafoneZiggo. Available at: https://www.acm.nl/en/publications/highest-administrative-law-court-netherlands-has-reversed-acms-decision-open-networks-kpn-and-vodafoneziggo

competition in the fixed market and to allow the ACM in future to ensure that companies that wish to become active in the Dutch telecom network will be granted access to a fixed telecom network.[291]

In May 2021, the ACM announced that it would publish a draft decision on provision of regulation of access to telecom networks in the coming months.[292] This will consider whether consumers and businesses could benefit from better price-quality ratios for broadband, TV and fixed telephony and will also consider potential future competition impact of KPN's current access conditions.

3.6.3.2 Initiatives for NGA provision

The Dutch telecommunications market is advanced, with a developed fixed infrastructure. In the Netherlands, NGA coverage is above the EU average – 98% of Dutch households have access to NGA services.[293] In 2019, very high capacity network coverage increased significantly by 57 percentage points, largely reflecting the upgrade of cable networks to DOCSIS 3.1.

In 2018, the national broadband plan was updated to include a connectivity action plan, targeting the provision of 100 Mbps-capable connections to all households by 2023. However, there is no national broadband funding scheme in the Netherlands. Instead, central authorities help regional and local authorities create the right conditions for market players to roll out fast internet by sharing knowledge and best practices. National legislation is in place to facilitate infrastructure sharing.

In July 2020, the Netherlands completed its first 5G auction, allocating nationwide 700MHz, 1400MHz and 2100MHz spectrum with a 20-year licence duration. The three incumbent MNOs - KPN, VodafoneZiggo, and T-Mobile Netherlands – were the winners. The licences include coverage obligations of 98% geographic coverage. However, it has been noted that there are administrative obstacles to the roll-out, with local governments being slow to issue the necessary permits. In spite of this, in October T-Mobile Netherlands stated that it had reached nationwide 5G coverage.[294]

3.6.3.3 Pro-competition policies

The ACM has supported cooperation amongst operators to promote the roll-out of high capacity broadband networks. This includes ACM's decision in February 2021 to allow mobile network operators to invest in joint infrastructure (sharing of locations for masts), spectrum leasing, and support national roaming using 2G and 3G networks (following operator's plans to switch off part of their legacy networks), in order to provide continuity for M2M services that need to be migrated to 4G or 5G.[295]

In the Netherlands, local municipalities and telecom providers are responsible for fibre network rollout. ACM monitors this market, and the 2019 market study identified potential obstacles to the rollout, such as time delays incurred due to multiple telecom providers planning to connect consumers and businesses in the same geographical location.[296] In response to this, the ACM published a handbook for municipalities that

[291] ACM, 28 May 2020, ACM granted additional powers to ensure Dutch telecom market will work better for people and businesses/ Available at: https://www.acm.nl/en/publications/acm-granted-additional-powers-ensure-dutch-telecom-market-will-work-better-people-and-businesses
[292] ACM, 9 July 2021, ACM explores regulation of access to telecom networks. Available at: https://www.acm.nl/en/publications/acm-explores-regulation-access-telecom-networks
[293] European Commission, 2021, DESI Report 2020 – Electronic communications markets overview. Available at: https://digital-strategy.ec.europa.eu/en/library/2020-desi-report-electronic-communications-markets-overview-member-state-telecom-chapters
[294] CMS, 2021, 5G Regulation and Law in the Netherlands. Available at: https://cms.law/en/int/expert-guides/cms-expert-guide-to-5g-regulation-and-law/netherlands
[295] ACM, 4 February 2021, ACM: telecom operators are allowed to work together for a fast roll-out of mobile networks. Available at: https://www.acm.nl/en/publications/acm-telecom-operators-are-allowed-work-together-fast-roll-out-mobile-networks
[296] ACM, 6 May 2021, ACM: fiber-optic roll-out experiences accelerated developments in the Netherlands. Available at: https://www.acm.nl/en/publications/acm-fiber-optic-roll-out-experiences-accelerated-development-netherlands

recommends co-investment solutions – i.e. the telecom providers should jointly invest in a single network with open access internet for all. As of May 2021, there were no co-investment projects for local fibre networks.

ACM also promotes competition through consumer choice and education. This includes a consumer information portal ACM ConsuWijzer.[297] Its objective is to educate consumers about their rights in the communications and other sectors, empowering consumers to select the products best suited to their needs and thereby promoting competition. However, from reviewing the website, it stops short of comparing retail bundles and prices.

In 2016, the ACM fined KPN, Tele2, T-Mobile and Vodafone for unfair commercial practices, namely for displaying incorrect and incomplete information about their mobile services on their website.[298] The ACM's investigation was triggered by consumer reports of unexpected costs and fees from telecom providers. For example, Vodafone advertised a plan that included a device, however, the advertised price was only available to Ziggo fixed broadband customers. Higher fees were applicable to new customers. We should note that the ACM does not currently regulate retail prices for fixed or mobile services.

A further example of ACM's policy aimed at promoting competition through consumer choice is the recently introduced policy rule, that will come into effect January 2022, to allow consumers to choose their own modem, router or decoder, provided that it meets the same requirements as the ISP provider's device.[299] ACM states that the policy will help lower switching barriers for consumers, promote consumer's free choice, and provide consumers with more control over their personal information and over data traffic on other terminal equipment (e.g., smart devices).[300]

At present, it appears that there is no regulated process for switching between fixed-mobile (or other) bundles in the Netherlands.

3.6.4 Provision and uptake of FMC bundles

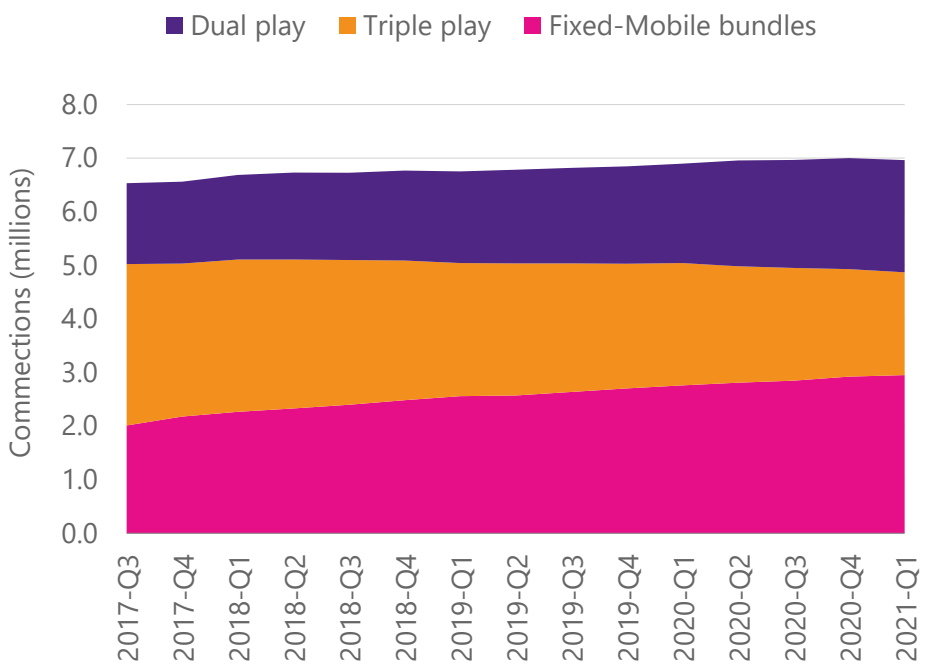
Bundled products dominate the fixed market, with an increase in dual play products – mostly fixed telephony and internet access.[301] Eurobarometer reports that 86% of fixed internet subscribers and 40% of mobile subscribers in the Netherlands bought their services as part of a bundle offer in February 2021.[302] In particular, including mobile services as part of a bundled subscription has become more popular; uptake has increased by 5 percentage points since April 2017.

The ACM reports subscriptions and connection types for mobile, fixed broadband and telephony, and subscription TV (including analysis on bundled services) on a quarterly basis.[303] Figure 3.9 shows the number of bundle subscriptions in the Netherlands between 2017 Q3 and 2021 Q1. The overall number of bundled connections grew by 6.6% from 6.53 million to 6.96 million. This was driven by a 46.7% increase in the number of fixed-mobile bundles over the period, from 2.01 million to 2.95 million fixed-mobile connections, and a 38.6% increase in dual play subscriptions (defined as fixed broadband and telephony). This growth was offset by a 36.2% decline in triple play bundles, from over 3 million connections to 1.9 million, as subscribers appear to be

[297] ACM, 2021, Consumer education: ACM ConsuWijzer. Available at: https://www.acm.nl/en/about-acm/consumer-education-acm-consuwijzer
[298] ACM, 30 December 2019, Four telecom providers fined for having unclear websites. Available at: https://www.acm.nl/en/publications/four-telecom-providers-fined-having-unclear-websites
[299] ACM, 2021, "Can I choose my own modem, router or decoder?". Available (in Dutch) at: https://www.acm.nl/nl/onderwerpen/telecommunicatie/klachten-telecom/kan-ik-mijn-eigen-modem-router-decoder-kiezen
[300] ACM, 27 July 2021, Consumers and businesses are allowed to choose their own modems. Available at: https://www.acm.nl/en/publications/consumers-and-businesses-are-allowed-choose-their-own-modems
[301] European Commission, 2021, DESI Report 2020 – Electronic communications markets overview. Available at: https://digital-strategy.ec.europa.eu/en/library/2020-desi-report-electronic-communications-markets-overview-member-state-telecom-chapters
[302] Eurobarometer, February 2021, E-Communications in the Single Market. https://europa.eu/eurobarometer/surveys/detail/2232
[303] Example from 2021 Q1. ACM, 29 July 2021, Telecom Monitor for Q1 2021. Available at: https://www.acm.nl/en/publications/telecom-monitor-q1-2021

selecting simpler bundles. The move away from triple-play is likely driven by consumers' substitution of traditional pay TV (e.g., cable, IPTV) services with VOD streaming platforms (e.g., Netflix).

Figure 3.9: Take-up of retail bundles by type



Source: ACM, quarterly Telecom Monitoring reports

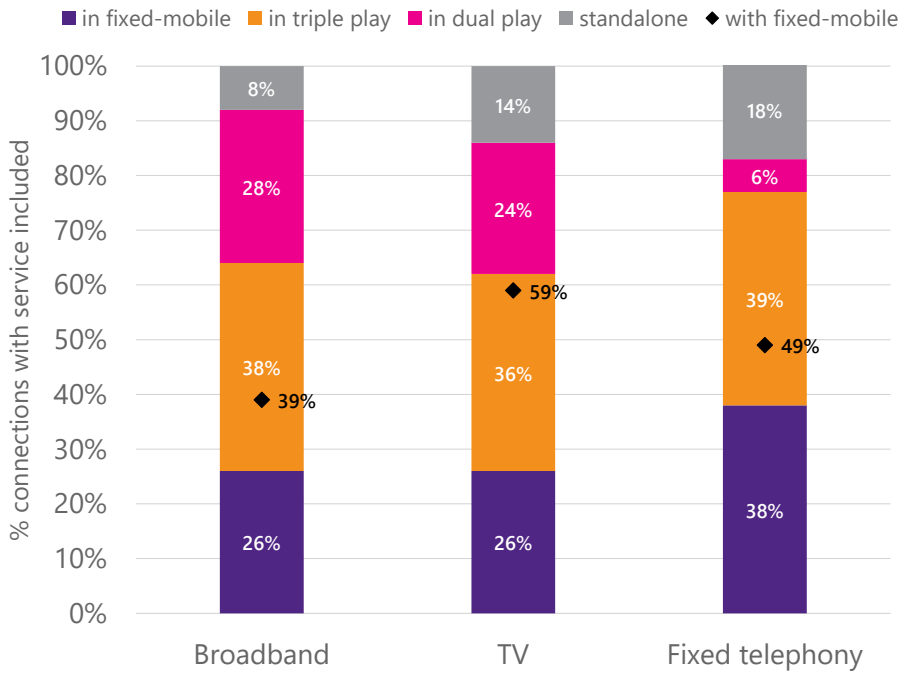
There is limited information on how increases in fixed-mobile and bundled subscriptions are affecting consumer switching behaviour, as the ACM reports churn statistics separately for each service and does not report mobile churn. Churn of fixed broadband services has been relatively stable since 2016 with some seasonality. However, churn of fixed broadband connections has marginally increased over 2020, potentially in response to the Covid-19 pandemic: there were 3.08% additions and 3.23% disconnected in 2021 Q1 (compared to 2.85% additions and 2.73% disconnected in 2017 Q3).

Figure 3.10 shows the uptake of different services (fixed broadband, TV and fixed telephony) as single or bundled services.[304] The ACM also reports the proportion of service subscriptions that are part of a bundle with fixed and mobile services – shown by the black diamond. Only 39% of fixed broadband subscriptions are part of a bundle with mobile, whereas 49% of fixed telephony subscription are part of a bundle with mobile. The proportion is higher for pay-TV subscribers (59%).[305] For simple mobile-fixed service bundles, the proportion of mobile and fixed telephony connections is higher (at 38%) than the proportion of mobile and fixed broadband connections (26%); though these figures do not take into account total subscriptions to each service. Uptake of each service is most commonly through a triple play subscription – representing 38% of broadband subscriptions, 36% of TV, and 39% of fixed telephony.

[304] Note, the ACM define dual play as a single fixed telecom and pay-TV service or two fixed telecom services, and triple play includes one or more fixed telecom with either a mobile subscription or pay-TV services.

[305] We note that 26% of pay-TV subscribers receive services through a fixed-mobile only subscription rather than triple play. ACM definition is unclear; however, our analysis of fixed-mobile offers suggests that this may capture complementary add-on TV/streaming services that offered as part of fixed-mobile subscription for no additional cost or for short-term trial. ACM data presented as reported for 2021 across different services.

Figure 3.10: Uptake of services in different bundled package types (2021 Q1)



Source: ACM, Telecom Monitoring report 2021 Q1. Note: dual play excludes mobile services.

3.6.5 Retail pricing of FMC bundles

In the Netherlands, all three fixed-mobile operators offer some form of discount for fixed-mobile subscriptions – though these tend to be relatively modest. The discount is typically applied to the mobile subscription rather than appearing as a combined fixed-mobile package that is lower in price.

Existing KPN Mobile subscribers who sign up to KPN's fixed services are offered a monthly €7.50 discount on their KPN Mobile subscription, and €5 discount when adding entertainment subscriptions such as Netflix, Spotify and ESPN.[306] The same offer is replicated for KPN's existing fixed subscribers when signing up for KPN Mobile. A typical fixed broadband package costs €47.50 (12-month contract) and a typical mobile contract is €27.50 per month for unlimited 5G mobile package.

T-Mobile NL offers existing mobile customers a €5 discount on their home internet subscription (€25/month instead of €30/month). Existing home (fixed internet) subscribers are offered a monthly €2.50 discount and additional 2GB data, rising to a €10 discount on unlimited data and unlimited calling packages and an unspecified discount on existing T-Mobile Home subscription.[307] Similar discounts are also offered for customers upgrading their existing fixed-mobile, fixed-mobile-TV and family mobile (more than one mobile subscription) services; such as by extending existing usage allowances.[308]

Although part of the same company, Vodafone and Ziggo operate separate websites for their retail offers. Both websites however host bundled offers to the other company. For example, Ziggo fixed customers can receive a monthly discount (typically between €2.50 and €5) and larger data allowances (typically doubled) when

[306] KPN offers reported as of 29/09/21: https://www.kpn.com/shop/internet-tv/internet?icid=toptaak2internet
[307] T-Mobile fixed offers reported as of 29/09/211: https://www.t-mobile.nl/mobiel-thuis/thuis
[308] T-Mobile offers for existing bundle customers reported as of 29/09/21: https://www.t-mobile.nl/klantvoordeel

subscribing to Vodafone SIM-only plans.[309] Similar discounts apply to Ziggo's Internet and TV subscription services and are summarised on Vodafone's website.[310]

3.6.6 Appraisal

The provision and take-up of fixed-mobile and other bundled services has been a result of several mergers between mobile, fixed telecom and cable operators, and discounts for customers taking up both fixed and mobile services from the same operator.

Bundled fixed internet and pay-TV services were launched in early to mid-2000s, with subsequent growth in take-up as operators developed their offerings. Take-up of bundled services has increased by 6.6% since 2017. At the same time has been significant decline in triple play services as consumers are switching to simpler fixed-mobile or dual play bundles. One possible reason is the substitution of pay-TV with OTT SVoD.[311]

Wholesale access regulation applied to the larger fixed networks, owned by KPN and Vodafone-Ziggo, in 2018 though this was later overturned. Subsequently, regulator ACM's powers have recently been strengthened to further support fixed network access and regulatory action. The ACM has provided support to local municipalities responsible for managing the local deployment of NGA networks and has publicly supported cooperation between operators to rollout of high quality 4G/5G networks. However, there have been no joint network investments to date.

As both the competition and sector regulator, the ACM has implemented several pro-competition policies to support ISP switching (for example, introducing measures to allow consumers to use own modem or router rather than ISP equipment) and maintains a consumer education site. The site does not act as an independent comparison site for different mobile, fixed and TV services, however.

[309] Vodafone offers for existing Ziggo fixed or TV customers, reported as of 29/09/21: https://directsales.ziggo.nl/ziggovoordeel?utm_medium=referrer&utm_source=ziggo&utm_campaign=cross-sell&utm_term=vodafone&utm_content=3-blokken

[310] Vodafone-Ziggo offers summarised, reported as of 29/09/21: https://www.vodafone.nl/daarom-vodafone/ziggo/gratis-extras

[311] Netherlands is among the leading markets for OTT SVoD services in Europe with household penetration at 55% as of 2019. Source: European Audiovisual Observatory, January 2021, Trends in the VOD market in EU29. Available at https://rm.coe.int/trends-in-the-vod-market-in-eu28-final-version/1680a1511a

3.7 Portugal

Motivation for selection: Significant government support for rollout of fixed next generation networks and market dominated by fixed-mobile conglomerates.

Key market & supply chain features	
Mobile network operators (subscriber share)	MEO (42-47%), Vodafone (24-29%) and NOS (24-29%) (2021 Q1)
Mobile virtual network operators	7 MVNOs. Significant MVNOs include: Lycamobile, NOWO, UZO and Yorn.
Other notable players in broadband supply chain	Fixed broadband operators: Grupo Altice (approx. 40%), Grupo ZON Optimus (approx. 35%), Vodafone (approx. 20%), and Grupo Apax (<5%). Grupo Altice includes the MNO MEO, Grupo ZON Optimus includes NOS and Grupo Apax includes the MVNO NOWO.
LTE coverage (% population)	99% population (2021 Q2)
5G coverage (% population)	No significant deployment; awaiting auction of 5G frequencies
Fast broadband coverage (% households)	83% (2020)
Very High Capacity Network (VHCN) coverage (% households)	83% (2020)
Mobile data usage (GB/month/sub)	4.45 (2020)
Fixed data usage (GB/month/sub)	300 (2020)
Mobile broadband penetration (% population)	78.95% (2020)
Fixed broadband penetration (% households)	115% (2020)
Population (million)	10.3 (2020)
Rural population (%)	33.4%
Households (million)	3.6
Land Area (sq.km)	91,606 (2020)
GDP per capita (US$, current)	22,440 (2020)

Source: Plum, CNMC (2020), GSMA Intelligence (2021 Q2), analysis by Opensignal (2021 Q1 values), World Bank (2018, 2020 values), ITU (2020), European Commission DESI (2020).

3.7.1 Market overview

As of Q1 2021, Portugal has almost 9 million mobile subscribers, of which 8.4 million are mobile broadband subscribers,[312] and 4.19 million fixed broadband subscribers.[313] Among fixed broadband subscribers, 56% are on FTTH, followed by cable at 28% and ADSL at 8%.[314]

[312] GSMA Intelligence, 2021
[313] CNMC, 2021. Informe Anual 2020 – refer to Fixed Communications. Available (in Spanish) at: http://data.cnmc.es/datagraph/jsp/inf_anual.jsp
[314] CNMC, 2021. Informe Anual 2020 – refer to Fixed Communications. Available (in Spanish) at: http://data.cnmc.es/datagraph/jsp/inf_anual.jsp

Mobile data consumption in 2020 was equal to 4.45 GB/month/subscriber which is below the OECD average of 7.54 GB.[315] The fixed broadband data consumption equals 300 GB/month/household.[316]

3.7.1.1 Mobile and fixed operators

As of 2021, Portugal has three main MNOs – MEO, Vodafone and NOS. Further, Portugal has a total of seven MVNOs with a reported approximate 3% market share.[317] Two MVNOs UZO and Yorn, are the sub-brands of MEO and Vodafone respectively.[318] Other notable MVNOs are Lycamobile (1.2% market share) and NOWO (1.3% share).[319]

Many of these MNOs and MVNOs also provide fixed broadband services as part of larger grouped entities. Portugal has four main fixed broadband providers – Grupo Altice (includes MEO), Grupo ZON Optimus (includes NOS), Vodafone, and Grupo Apax. Grupo Altice (includes MVNO NOWO).[320] More detail on fixed market shares, technologies deployed, and the broadband packages are outlined below.

- **Grupo Altice** is the largest fixed broadband provider in Portugal, with an approximate 40% (as of Q1 2021) subscriber market share[321], and the largest MNO (both fixed and mobile services are offered under the MEO brand). The Altice group is the largest provider of bundled broadband packages in Portugal. As of 2020, its bundled product offerings had a market penetration of 40.5%. MEO predominantly offers fixed FTTH services.[322] MEO's bundled packages include TV-net-voice-mobile and TV-net-voice. Average price for the former is around €30[323] for starting packages while packages with mobile bundling cost around €50[324] per month. In comparison a mobile-only package costs around €15 monthly.[325]

- **Grupo Zon** is the second largest fixed broadband provider in Portugal with an approximate market share of 35% (Q1 2021). The group entities are Optimus, the NOS mobile and regional provider brands,[326] and ZON TV CABO which is the leading pay-TV provider in Portugal.[327] Group Zon provides fibre and satellite-based fixed broadband services. The fibre, TV-net-voice packages average around €30 per month[328] and the satellite TV-net packages cost around €35 per month.[329] In comparison the mobile only packages are priced at around €20 per month.[330]

- **Vodafone** has a fixed market share of approximately 20%. Vodafone is the third largest player in both fixed and mobile markets. Vodafone's share of fixed broadband bundled offerings (including mobile and/or pay-TV) was 19.3% in 2020.

- **Grupo NOWO** is the smallest fixed broadband provider in Portugal, with a market share of 3% (Q1 2021). The group includes Cabovisão, NOWO and Onitelecom. Both NOWO and Onitelecom operate as

[315] OECD, 2021, OECD broadband data portal. Refer to '1.13. Mobile data usage per mobile broadband subscription (Dec. 2020).' Available at: https://www.oecd.org/sti/broadband/broadband-statistics/
[316] CNMC, 2021. Informe Anual 2020 – refer to Fixed Communications. Available (in Spanish) at: http://data.cnmc.es/datagraph/jsp/inf_anual.jsp
[317] Sources: GSMA Intelligence, 2021, and BuddeComm, 15 March 2021, Portugal Telecoms Market Report. Available at: https://www.budde.com.au/Research/Portugal-Telecoms-Mobile-and-Broadband-Statistics-and-Analyses
[318] GSMA Intelligence, 2021.
[319] ANACOM, July 2021, Mobile services - 1st quarter 2021
[320] ANACOM, July 2021, Internet access service at a fixed location - 1st quarter 2021. Available at: https://www.anacom.pt/render.jsp?contentId=1671938
[321] ANACOM, 2021, Internet access service at a fixed location - 1st quarter 2021
[322] MEO, 2021, Available at: https://www.meo.pt/servicos/casa/internet-fibra/melhor-experiencia-net
[323] MEO, 2021, Available at: https://www.meo.pt/servicos/casa/fibra/pacotes-em-destaque
[324] MEO, 2021, Available at: https://www.meo.pt/servicos/casa/fibra/pacotes-com-telemovel
[325] MEO, 2021, Available at: https://www.meo.pt/servicos/movel/tarifarios-telemovel/pos-pago/m-move l
[326] NOS brands include NOS Comunicações, ZON Madeira / NOS Madeira, ZON Açores / NOS Açores and ZON TV CABO Portugal
[327] NOS, 2021, ZOS – Learn the history of the company. Available at: https://www.nos.pt/institucional/EN/about-nos/about-us/Pages/zon-history.aspx
[328] NOS, 2021, TV-net-voice: Fibre. Available at: https://www.nos.pt/particulares/pacotes/todos-os-pacotes/Paginas/pacotes.aspx#tabpanel-one
[329] NOS, 2021, TV-net-voice: Satellite. Available at: https://www.nos.pt/particulares/pacotes/todos-os-pacotes/Paginas/pacotes.aspx?tipo=satelite#tabpanel-one
[330] NOS, 2021, Like Tariff. Available at: https://www.nos.pt/particulares/telemovel/tarifarios/Paginas/like.aspx?LPTarifarios#3

MVNOs hosted on MEO's network. The group's market penetration of the bundled offerings stands at 3.5% (2020). NOWO offers both FTTP and FTTC packages. Its TV-net-voice package costs around €15 per month for both fibre and hybrid fibre packages.[331] TV-net-voice-mobile packages cost around €25 for both hybrid and full-fibre offerings.[332] Onitelecom offers business to business (B2B) fixed and mobile services. It provides both mobile and fixed services, with details of packages available only upon request.[333]

Rural fibre provider Fibroglobal and dstelecom provide wholesale access to their fibre infrastructure. This is used by MEO, NOS and Vodafone to provide fibre to customers in areas where they do not have their own fibre networks.[334]

3.7.1.2 Changes in market structure

There have been several developments that have contributed to changes in the market structure in Portugal. The merger between Altice Portugal (part of Altice Group, a French company) and PT Portugal was controversial in that it led to litigation over several years and a large fine for Altice for implementing the acquisition before an approval by the European Commission. The logic of the merger was to create a stronger player in both fixed and mobile markets.[335,336]

In 2013, there was the merger of Zon, a cable company, and Optimus, a full-service telecoms provider, aimed at strengthening a full market proposition.[337] The merger was allowed with conditions:

- An agreement by Optimus not to charge its fibre-to-the-home (FTTH) customers a network disconnection charge for a period of six months.
- Optimus to provide non-discriminatory access to its FTTH network on a wholesale basis for a period of five years.

In 2017 Vodafone Portugal and NOS entered into an agreement to deploy and share a fibre-to-the-home network which will be marketable to around 2.6 million homes and businesses in Portugal. The arrangement involved the two companies providing reciprocal access to each other's networks on commercially agreed terms.[338]

3.7.2 Policy and regulatory environment

3.7.2.1 Fixed access regulation

In July 2017, the Portuguese Government passed a law strengthening the measures to reduce the cost of deploying high-speed communications networks in line with EU's *2014 Directive No. 2014/61/EU*. The main objectives of the law are to:[339]

[331] NOWO, 2021, TV-net-voice. Available at: https://www.nowo.pt/pacotes/tv-net-voz/
[332] NOWO, 2021, TV-net-voice-mobile. Available at: https://www.nowo.pt/pacotes/tv-net-voz-movel/
[333] ONI, 2021, Internet. Available at: https://www.oni.pt/en/internet-2/
[334] Telegeography, 12 June 2019, Fibroglobal agrees to slash wholesale fibre prices; dstelecom reaches subscriber milestone. Available at: https://www.commsupdate.com/articles/2019/06/12/fibroglobal-agrees-to-slash-wholesale-fibre-prices-dstelecom-reaches-subscriber-milestone/
[335]https://ec.europa.eu/competition/mergers/cases/decisions/m7499_999_2.pdf
[336] https://altice.net/sites/default/files/pdf/150123-acquisition-portugal-telecom.pdf
[337] https://www.commsupdate.com/articles/2013/08/28/competition-authority-grants-final-approval-for-zon-optimus-merger/
[338] https://www.vodafone.com/news/press-release/vodafone-portugal-and-nos-fibre-network-share-agreement-in-portugal
[339] ANACOM, 31 July 2017, Decree-Law no. 92/2017. Available at: https://www.anacom.pt/render.jsp?contentId=1418606

- facilitate and encourage the implantation of high-speed electronic communications networks,
- promote the joint use of existing infrastructures,
- foster an efficient implantation of new physical infrastructures and intersectoral coordination.

To achieve the above objectives, amongst other measures, the law mentions the establishment of an 'Information System on Suitable Infrastructures' which would require the operators to keep an updated record on the suitable infrastructures they hold. For example, ducts, manholes, inspection chamber and associated infrastructures. If requested, the operators would need to share this information with the regulator or another firm making a request for infrastructure sharing.

3.7.2.2 Initiatives for NGA provision

The Portuguese government has implemented several policies and regulations, and provided funding (through tax aid schemes) to support the roll out of next generation networks.

In July 2008, the government passed the strategic guidelines for the development and promotion of investment in next generation networks. The main objectives included evolution and development of the communications sector, provision of high-speed applications, provision of innovative services, expected increase in foreign investment, economic growth in the form of GDP increase and consumer welfare.[340]

In March 2009, the Portuguese Government introduced the Investment and Employment initiative to further promote economic growth, encourage employment generation and modernisation of the Portuguese economy through investment in multiple sectors, including the next generation broadband networks. The financing of the initiative would be through state-funding along with community financing, which would apply to both fixed and mobile technologies.

As a supplementary financial instrument to this initiative, the tax aid scheme was also announced, wherein operators investing in the next generation broadband networks in 2009 could seek tax rebates.[341]

In January 2011, the government approved the regulation to deploy next generation broadband networks in rural areas. The objectives of the regulation are to provide equal opportunities to all citizens, social and economic development of the rural areas, enhancement of human capital and e-inclusion. The state would provide financial support (in the form of non-reimbursable subsidy) for the implementation of this regulation.[342]

In February 2020, the Portuguese government published a 13-point strategy mapping out 5G adoption in Portugal.[343] This assigned specific actions to ANACOM and the government, such as assignment of spectrum and assessing potential financing tools and policies to promote 5G adoption. The government's strategy also sets milestones for 2020, 2023, 2024 and 2025 relating to 5G network coverage.

Notably, however, Portuguese operators are yet to launch 5G services due to spectrum availability. ANACOM's 5G auction was delayed by the Covid-19 pandemic and by further legal challenges.[344] The main bidding phase of the 5G auction concluded on 27 October 2021 and raised a total of €556 million. The auction offers frequency

[340] ANACOM, 30 July 2008, Establishes the strategic guidelines for the development and promotion of investment on next generation networks. Available at: https://www.anacom.pt/render.jsp?contentId=984614
[341] ANACOM, 10 March 2009, Law no. 10/2009 – Investment and Employment Initiative. Available at: https://www.anacom.pt/render.jsp?contentId=976722
[342] ANACOM, 18 January 2011, Deployment of Next Generation Broadband Networks in Rural Areas. Available at: https://www.anacom.pt/render.jsp?contentId=1065914
[343] As outlined by Portugal's Resolution of the Council of Ministers No. 7-A/2020: https://dre.pt/home/-/dre/129106697/details/maximized
[344] Reuters, 27 October 2021, Portugal's delayed 5G auction wraps up, raising 566 million euros. Available at: https://www.reuters.com/technology/portugals-delayed-5g-auction-wraps-up-raising-566-million-euros-2021-10-27/

rights in the 700 MHz, 900 MHz, 1800 MHz, 2100 MHz, 2.6 GHz and 3.5 GHz bands.[345] Final frequency allocations to and payments from operators are yet to be announced at the time of writing.

3.7.2.3 Pro-competition policies

The *Electronic Communications Law* governs the electronic communications sector in Portugal. While the law lays out the fundamentals of running the sector, its functionality is more in terms of the operators complying with it and sending notifications or declarations to the regulator rather than seeking any authorisation from the regulator.[346]

Objectives of the law include promotion of competition in the provisions of telecommunications networks and services, promoting the interest of the citizens, and encouraging investment and innovation. Several important provisions are highlighted below.[347]

- Operators to promote co-location and facility sharing (including duct, building or mast sharing);
- Operators to publish clear and complete information related to their quality of service;
- Operators to regularly provide updates to the regulator on the quality of service;
- Operators with significant market power would need to comply with certain regulatory obligations, such as the: obligation to respond to requests for access and interconnection; obligation to ensure transparency in the publication of information to facilitate these requests, including technical specifications, network characteristics, accounting information; obligation to practice non-discrimination in relation to provision of access, interconnection, and publication of information; and obligation on price control and cost-recovery, if the market analysis indicates lack of effective competition.
- ANACOM can fine operators for breach of obligations, which may cost between €5,000 and €5 million.
- Operators are ensured rights of way (including right to use public domain and request expropriation) for the installation of necessary and indispensable network infrastructure for the provision of their services.
- Users' rights provisions including equal access to network and services; written information on the terms and conditions of the service prior to the conclusion of any contract; terms and conditions of the contract should include (for example, identity and address of the operator, service provided, quality of service to be offered, types of maintenance services offered, price details and any compensation terms that apply if service quality is not met); and, minimum of 15 days' notice in the event of network termination.

In addition, there are several other targeted regulations specific to different technicalities of providing an efficient and effective communications service in Portugal. These include:

- *Decree-Law No. 123/2009* and its various amendments thereafter including the recent Law No. 95/2019 – that focuses on the construction of suitable infrastructure for providing the telecommunications in varied spatial settings like urban settlements, housing developments and concentration of buildings;
- *Law applicable to radio communication networks and stations* (Decree-Law No. 151-A/2000);

[345] Further details on bidding rounds if available from ANACOM's website: https://www.anacom.pt/render.jsp?categoryId=416583
[346] Lexology, June 2021, In brief: telecoms regulation in Portugal. Available at: https://www.lexology.com/library/detail.aspx?g=e70db904-e078-4680-9bbc-ffd6cc0a0cae
[347] ANACOM, 10 February 2004, Law applicable to the electronic communications. Available at: https://www.anacom.pt/render.jsp?contentId=975162

- *Regime for user protection and essential public services* (Law No. 23/96); and
- *Law on the use of radio equipment* (Law No. 57/2017).

3.7.2.4 Other considerations

ANACOM has opened a consultation to decide on the strategic objectives for the communications sector for the years 2022-2024. Key areas outlined by ANACOM for the development of these strategic objectives include – digital transformation of the society, improving the Portuguese competitiveness in the global digital economy, introduction of 5G mobile networks, emergence of new models of co-use and infrastructure sharing and green digital transition.[348]

3.7.3 Provision and uptake of FMC bundles

According to the latest Eurobarometer, 50% of households subscribe to mobile services as part of a bundle from the same provider, while 68% subscribe to fixed broadband services as a bundle from the same provider. This is above the EU average of 36% and 45% respectively.[349]

ANACOM's 2020 annual market report[350] indicates that bundled subscriptions have reached 4.2 million at the end of 2020, recording 4.4% annual growth mainly associated with Quadruple/Quintuple play (112,000 additional subscriptions; 2.1 million subscriptions in total) and Triple play (85,000 additional subscriptions; 1.7 million subscriptions in total).

The report also lists the uptake bundles by composite services, as shown in Figure 3.11 below. Based on these definitions and our survey of retail offerings in Portugal, it appears that no operator offers fixed-mobile only services, i.e., any package offering fixed-mobile services also include subscription TV services.[351] Fixed-mobile bundles (i.e. quadruple/quintuple play) account for 50.3% of bundle subscriptions. Figure 3.12 shows the average annual growth and the cumulative growth in bundle subscriptions.

Figure 3.11: Portugal bundle package type and average prices (Dec 2020)

Bundle type	Service composition	Average price (Dec 2020, €)
Dual play	Fixed broadband and subscription TV; Fixed broadband and fixed telephony; or Subscription TV and fixed telephony	21.56 21.56 13.49
Triple play	Fixed broadband, fixed telephony and subscription TV	23.96
Quadruple play	Fixed broadband, fixed telephony, subscription TV and mobile (voice only); or Fixed broadband, fixed telephony, subscription TV and mobile (voice and data)	28.75 28.75

[348] ANACOM, 16 July 2021, "Consultation on strategic guidelines for 2022-2024." Available (in Portuguese) at: https://anacom.pt/render.jsp?contentId=1680105

[349] European Commission, June 2021, E-Communications in the Single Market. Available at: https://europa.eu/eurobarometer/surveys/detail/2232

[350] ANACOM, 13 Maye 2021, *O SECTOR DAS COMUNICAÇÕES*. Available (in Portuguese) at: https://www.anacom.pt/streaming/SectorComunicacoes2020.pdf?contentId=1635852&field=ATTACHED_FILE

[351] It is notable that OTT SVoD penetration in Portugal (22% in 2019) is the lowest among the FMC markets and this is reflected in the level of pay-TV penetration (97% households in 2019) and the prevalence of quadruple- and quintuple-play bundles. Source: European Audiovisual Observatory.

Bundle type	Service composition	Average price (Dec 2020, €)
Quintuple play	Fixed broadband, fixed telephony, subscription TV and mobile (voice and data) and mobile broadband for PC/tablet	54.53

Source: ANACOM, Communication Sector 2020 report.

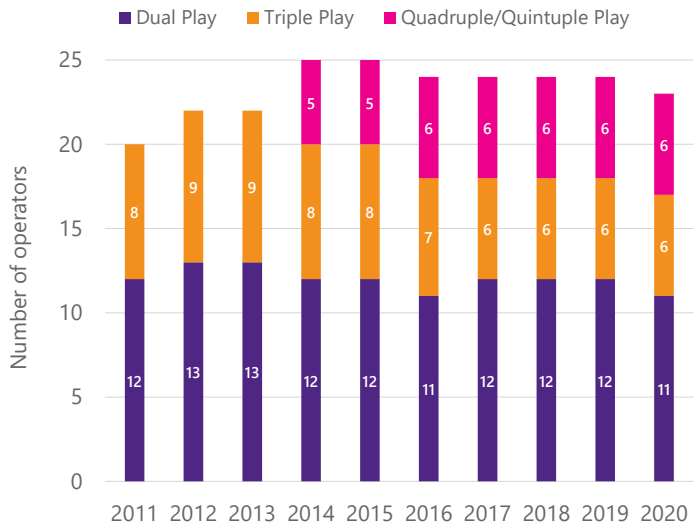
Figure 3.12: Average annual growth and cumulated growth of bundle subscriptions by bundle type (2016-2020)

Bundle type	Average annual growth (2016/2020) (%)	Cumulated growth (2016/2020) (%)
Dual play	-5	-18.5
Triple play	4.2	18
Quadruple/Quintuple play	8	36.1

Source: ANACOM, Communication Sector 2020 report.

There are a high number of bundled service providers in Portugal, a total of 11 providers, including fixed-mobile operators and MVNOs/reseller, of which six offer triple or quadruple play bundles.[352] Figure 3.13 below shows the evolution of bundled package providers in Portugal over the last ten years, and growth in the number of providers offering quadruple and quintuple bundles (i.e. bundles that include mobile services). Quadruple/quintuple packages represented 63% of the total revenue.[353]

Figure 3.13: Bundled package providers (2011-2021)



Source: ANACOM

In terms of the subscriber market penetration of all bundled offers, Grupo Altice is the leader at 40.5%, followed by Grupo NOS at 36.5%, Vodafone at 19.3% and Grupo Apax at 3.5%. However, there is no clear trend in the

[352] ANACOM, 13 May 2021, The communications sector 2020: Communications sector statistical annex 2020. Available at: https://www.anacom.pt/render.jsp?contentId=1635851

[353] ANACOM, 7 June 2021, "Packages in communication services." Available (in Portuguese) at: https://www.anacom.pt/streaming/Pacotes21T1_v20210607.pdf?contentId=1653821&field=ATTACHED_FILE

penetration of bundled offers; for example, by number or by type of services including within the bundle.[354] MEO has the largest share of subscribers in dual-play (43.4%) and triple-play offers (38.2%), and Grupo NOS recorded the largest share in the quadruple/quintuple-play offers (42.9%).[355]

3.7.4 Retail pricing of FMC bundles

In Portugal, operators and resellers (including MVNOs) commonly offer fixed and mobile services as part of packages that include TV subscriptions. The most common type of package is a fixed broadband, voice and TV bundle and operators commonly also offer a quadruple-play bundle which includes mobile services.

In the survey of operator websites, we did not identify any operator that offers fixed-mobile only packages (i.e., excluding TV services in combined offers) nor any operator that offers discounts to existing subscribers when they take out an additional service. The three leading fixed-mobile operators MEO (Grupo Altice), NOS (Grupo ZON) and Vodafone offer packaged services, namely fixed voice and broadband with TV subscription or fixed and mobile services with TV subscription.[356] The composition of packaged services and lack of discounting suggests that provision of entertainment services is a key commercial advantage for consumers in this market.

ANACOM's 2020 annual market report indicates that during 2020, there were some changes in the available commercial offers. For example, NOWO reduced its monthly fee for mobile cards integrated in bundled offers from €7.50 to €5. Triple-play satellite offers have also recorded a monthly fee reduction by some providers, moving closer to the monthly fees for fibre offers. Meanwhile Vodafone and NOS have both marginally increased monthly fees for triple-play offers, from €29.90 (Vodafone) and €29.99 (NOS) in 2019 to the same price of €30.90 in 2020. The regulator has additionally reported a reinforcement of some bundled offers with streaming services, such as Amazon Prime Video and HBO, included in some Vodafone bundles.

3.7.5 Appraisal

Both market and policy factors have a role in the fixed-mobile convergence in Portugal. The critical market factor for convergence appears to be the high level of consolidation between the telecommunication operators. The market is dominated by several grouped entities that offer fixed, mobile and bundled services and have access to their own or external backhaul to support these services. MVNOs and fixed ISP resellers have replicated the main operator bundles, and there is a high uptake of complex bundle products (i.e., 4P/5P fixed-mobile with pay-TV services).

The Portuguese government has launched several policies to deliver next generation networks and deliver digitisation. These policies have promoted multi-service networks since 2008. The government has also introduced a tax aid scheme for operators investing in fixed or mobile next generation broadband networks (highlighted in Section 3.7.2.2). Further, Portugal's telecommunications law emphasised infrastructure sharing and good transparency on infrastructure related information which has directly facilitated the process of convergence. This includes obligations such as facility sharing and providing regular quality of service updates, and SMP obligations to provide access and interconnection services.

[354] ANACOM, 2021, Internet access service at a fixed location - 1st quarter 2021.
[355] ANACOM, 2020, The communications sector 2020: Communications sector statistical annex 2020.
[356] Offers of leading fixed-mobile operators in Portugal reviewed on 29/09/21.

3.8 Spain

Motivation for selection: Extensive fibre deployment and infrastructure sharing between operators has increased operators' ability to provide fixed and mobile retail services. Bundled offers are replicated by MVNOs and resellers.

Key market & supply chain features	
Mobile network operators (subscriber share)	Movistar (27-32%), Vodafone (20-25%), Orange (25-30%), Yoigo/Masmovil (16-21%) (Q1 2021)
Mobile virtual network operators	77 MVNOs
Other notable players in broadband supply chain	Fixed ISPs include MNOs Movistar (approx. 30%), Vodafone (approx. 25%), Orange (approx. 28%) and smaller players Masmovil and Euskatel
LTE coverage (% population)	99.9% population (2021 Q2)
5G coverage (% population)	80% population (2021 Q2)
Fast broadband coverage (% households)	90% (2020)
Very High Capacity Network (VHCN) coverage (% households)	89% (2020)
Mobile data usage (GB/month/sub)	5.4 (2020)
Fixed data usage (GB/month/sub)	236.1 (2020)
Mobile broadband penetration (% population)	105.29% (2020)
Fixed broadband penetration (% households)	97% (2020)
Population (million)	47.35 (2020)
Rural population (%)	19.2%
Households (million)	16.3
Land Area (sq.km)	499,604 (2020)
GDP per capita (US$, current)	27,057 (2020)

Source: Plum, CNMC (2020), GSMA Intelligence (2021 Q2), analysis by Opensignal (2021 Q1 values), World Bank (2018, 2020 values), ITU (2020), European Commission DESI (2020).

3.8.1 Market overview

As of 2020, Spain has a total of 47.8 million mobile subscribers for voice and data[357] and 16.2 million fixed broadband subscribers.[358] The annual mobile data consumption in 2020 amounted to 3.1 million TB which is roughly equal to 5.4 GB monthly per user. In comparison, annual fixed data consumption in 2020 was 46.3 million TB or an equivalent of 236.1 GB per household per month. [359] Overall turnover of the electronic communications industry in 2020 was approximately €32.6 billion, of which 16% comes from mobile services and 13% comes from fixed broadband services.[360]

[357] CNMC, 2021, Informe Anual 2020, "4. Comunicaciones Móviles". Available (in Spanish) at: http://data.cnmc.es/datagraph/jsp/inf_anual.jsp
[358] CNMC, 2021, Informe Anual 2020, "3. Comunicaciones Fijas". Available (in Spanish) at: http://data.cnmc.es/datagraph/jsp/inf_anual.jsp
[359] CNMC, 2021, Informe Anual 2020.
[360] CNMC, 2021, Informe Anual 2020.

As of 2020, FTTP networks in Spain covered 80% of the households, above the EU average of 34%. Rural FTTP coverage in Spain is at 46%, which is much higher than both the EU rural coverage and total FTTP coverage (21% and 34% respectively).[361]

Spain has four main MNOs – Movistar, Vodafone, Orange and Yoigo (Masmovil).[362] Grupo Masmovil started its operations in 2017. Yoigo was acquired by the Masmovil group in 2016 but has retained the Yoigo brand for its mobile servicers. [363,364]

Masmovil also operates in Spain as an MVNO, under both an eponymous brand as well as other brands (including Best Movil, Cablemovil, Embou, Guuk). Twelve of Spain's 77 MVNOs are the part of the Masmovil group. Only three are hosted on Yoigo's networks and the others are hosted on Movistar, Vodafone, and Orange's networks.

Spain has five main fixed broadband providers. In addition to the retail services, each fixed operator, apart from Euskatel, also holds a significant share of the wholesale access and fixed interconnection service markets. BT and Telecom Italia also provide wholesale services in Spain, though Movistar is the leader in wholesale access in Spain. Fixed ISPs tend to use a combination of both their own and others' networks to provide retail services.[365] Details of fixed ISP market shares, product packages and technology deployed are summarised below.[366]

- **Movistar** has the largest market share (as of 2020) with 36% of fixed subscribers. It provides fibre-based services and bundled packages.

- **Orange** is the second largest fixed ISP, with 24% market share in 2020. Orange also offers various other bundled packages, comprising fixed telephony and broadband, mobile and pay-TV services. This includes 4G 'at home' option with a 4G Wi-Fi router offering speeds up to 150 Mbps.[367]

- **Vodafone** has a 20% market share (2020) and provides fibre-only products. Its starter TV-fibre-mobile packages cost between €30 and €360 per month (with a 50% discount for the first six months).[368] The cost of its fibre broadband service varies by connection speed from 600 Mbps (€30/month) to 1 Gbps (€40/month).[369]

- **Masmovil** holds a 16% share of the fixed market and provides FTTP and FTTC services.[370] Masmovil recently acquired Euskatel, previously the fifth-largest fixed player.[371] Euskatel was a regional operator in Northern Spain (including in Basque Country, Galicia, and Asturias).[372] In May 2020 it launched mobile, broadband and TV bundles nationwide under the Virgin brand. Masmovil also operates as an energy provider and does not charge the monthly service fee of €6 from its energy customers, if they are subscribers to Masmovil's telecommunication services.[373]

[361] European Commission, 2021, DESI Report 2020 – Spain Telecom Chapter. Available at: https://digital-strategy.ec.europa.eu/en/library/2020-desi-report-electronic-communications-markets-overview-member-state-telecom-chapters
[362] There are also several regional operators providing broadband wireless access and enterprise data services using spectrum in the 2.6 GHz and 3.6 GHz bands. One example is COTA (Consorcio De Telecomunicaciones Avanzadas).
[363] MASMOVIL, 7 September 2016, Communication of a Relevant Fact. Available at: https://www.grupomasmovil.com/wp-content/uploads/2017/01/070916_Aprobacion_CNMC_Yoigo_ENGLISH.pdf
[364] GSMA Intelligence, 2021.
[365] CNMC, 2021, Informe Anual 2020, "6. Servicios Mayoristas". Available (in Spanish) at: http://data.cnmc.es/datagraph/jsp/inf_anual.jsp
[366] CNMC, 2021, Informe Anual 2020.
[367] Orange, 2021, 4G at home. Available at: https://tiendaonline.orange.es/tarifas/internet/4g-en-casa?_ga=2.227303327.389131361.1630599063-559570452.1630599063
[368] Orange, 2021, Fiber and Mobile. Available at: https://www.vodafone.es/c/particulares/es/productos-y-servicios/vodafone-one/
[369] Vodafone, 2021, Fibre optic rates. Available at: https://www.vodafone.es/c/particulares/es/productos-y-servicios/fibra-optica-adsl/
[370] Market share estimated using latest available data for MasMovil and Euskatel.
[371] Mobile World Live, 17 June 2021, Spanish regulator approves Masmovil, Euskaltel deal. Available at: https://www.mobileworldlive.com/featured-content/top-three/masmovil-euskaltel-clearance
[372] Euskatel, 2021, The Company. Available at: https://www.euskaltel.com/en/corporate /about-us/company
[373] Masmovil, 2021, Electricity. Available at: https://www.masmovil.es/otros-servicios

3.8.2 Changes in market structure – FMC mergers

Much of the Spanish market is controlled by the three nationwide operators: Movistar, Orange and Vodafone. These three operators rely on a multi-brand strategy to appeal to different market segments, using separate brands to offer cheaper 'no frills' services.

The current market structure is a result of consolidations in the sector. In 2014 Vodafone bought out smaller player Ono; in 2015 Orange bought out Jazztel. Both of these players offered both fixed and mobile services.

The buyout of Jazztel reduced the number of nationwide fixed broadband providers from four to three. The merger was subject to additional conditions from the European Commission, which expressed concerns that the merger would reduce competitive pressure in the market.[374] To address these concerns, Orange offered to (1) divest an optical fibre network covering 700-800k premises; (2) grant wholesale access to its copper network; and (3) provide wholesale access to its mobile network to access seekers on favourable terms.

The conditions of the merger provided a window of opportunity for smaller rival Masmovil: in 2015 it bought network assets that Orange was required to sell off.[375] This led to significant increases in its customer base, profit and market value.

In August 2021 Masmovil took over the fifth market player Euskatel, Euskatel was a regional player in northern Spain. In May 2020 it launched nationwide, offering mobile, broadband and TV bundles under the Virgin brand. The merger combined the fourth and fifth largest telecommunications players.

In March 2021 it was reported that Masmovil and Vodafone were in discussions about a possible merger.[376] Such a merger would again take the number of nationwide telecommunications providers to three.

3.8.3 Policy and regulatory environment

The National Commission of Markets and Competition (CNMC) is the telecoms sector regulator in Spain and is responsible for regulating competition and sectors including energy and transport. The key objective of CNMC is to guarantee, preserve and promote effective competition and transparency in the markets it regulates. It is an independent body under the parliamentary oversight.[377]

3.8.3.1 Fixed access regulation

The four nationwide operators each operate FTTH networks. Of these, former incumbent Telefonica's network is the most extensive, with 24 million premises passed (out of a total 25 million residential and business premises nationwide).

From 2008, Telefonica has been obliged to grant regulated access to its passive infrastructure (civil engineering infrastructure) at cost-oriented prices.[378] Duct access is actively used by alternative operators to deploy their own FTTH access networks, with 26,500 km of shared ducts. The regulator imposed a symmetric obligation on the first-to-building operator to grant access to in-building fibre.

[374] European Commission, 19 May 2015, Mergers: Commission clears acquisition of Jazztel by Orange, subject to conditions. Available at: https://ec.europa.eu/commission/presscorner/detail/en/MEMO_15_4998
[375] Financial Times, 9 June 2020, Pain in Spain for telecoms groups as competition heats up. Available at: https://www.ft.com/content/97bbe090-ca2d-4634-bc11-311689ff536f
[376] telecoms.com, 11 March 2021, MasMovil Vodafone merger talk refuses to die. Available at: https://telecoms.com/508971/masmovil-vodafone-merger-talk-refuses-to-die/
[377] CNMC, 2021, What is CNMC? Available at: https://www.cnmc.es/en/sobre-la-cnmc/que-es-la-cnmc#objetivo
[378] SIPOTRA, January 2021, Country Reports – Spain. Available at: https://www.sipotra.it/wp-content/uploads/2020/01/Spain.pdf

A regulatory decision in 2016 introduced geographically differentiated access requirements. Under these proposals Telefonica was obliged to provide: (1) fibre local loop virtual unbundling (VULA) termed NEBA local, and (2) broadband access (called NEBA fibra). These services are sold without a bandwidth limitation and at cost-oriented prices. However, Telefonica is *not* obliged to offer these services in 'competitive areas', defined as areas in which: (i) there are at least 3 NGA networks with coverage of at least 20%; and (ii) Telefónica's share in the retail market of broadband does not exceed the 50% threshold. On this basis, initially 66 municipalities were designated 'competitive areas'.[379]

In June 2021, the CNMC relaxed the criteria for defining a 'competitive area'.[380] This resulted in an expansion the number of competitive areas to 624 municipalities, comprising around 68% of the Spanish population.

In Spain, access to fixed NGA infrastructure is also underpinned by commercial arrangements. For example, in 2018 Orange and Telefonica struck a deal to allow Orange access to Telefonica's network in areas where Orange is not planning to deploy its own network.[381] A similar deal was struck between Telefonica and Vodafone in 2017.

3.8.3.2 Initiatives for NGA provision

Spain has one of the most advanced fibre networks in Europe – around 80% of Spanish households have access to FTTP services. However, there are significant differences in service coverage between urban and rural areas (although both are well above the EU average).[382] Concerns about the digital divide has prompted action to support the rollout of services in underserved areas, through the Programa de Extensión de la Banda Ancha de Nueva Generación (PEBA-NGA) programme.[383] This will provide a total of €400m through to the end of 2022 to support FTTP deployment in underserved areas.

In 2020, Spain's Ministry of Economic Affairs and Digital Transformation (MAETD) published the Digital Spain 2025 plan to promote digital transformation in Spain. The financial goal is to incur a public and private investment of around €70bn from 2020 to 2025. The new telecommunications law is an important agenda point of the Digital Vision as well. The ten 'strategic axes' of the vision are:[384]

- Digital connectivity: reduce the digital divide and provide 100% of the population with 100 Mbps coverage by 2025.
- 5G technology: lead 5G deployment in Europe, encouraging its contribution in socio-economic growth of the country and have 100% of the radio spectrum ready for 5G by 2025.
- Digital skills of workers and the general public: 80% of people (of which 50% should be women) to have basic digital skills by 2025.
- Cybersecurity: to have 20,000 specialists in cybersecurity, Artificial Intelligence, and data by 2025.

[379] CNMC, 3 March 2021, "Resolución de 24 de febrero de 2016, de la Comisión Nacional de los Mercados y la Competencia, por la cual se aprueba la definición y análisis del mercado de acceso local al por mayor facilitado en una ubicación fija y los mercados de acceso de banda anch ." Available (in Spanish) at: https://www.cnmc.es/novedades/2016-03-03-resolucion-de-24-de-febrero-de-2016-de-la-comision-nacional-de-los-mercados-y
[380] CNMC, 17 June 2021, "RESOLUCIÓN ... ANME/DTSA/002/20/MERCADOS ACCESO LOCAL CENTRAL ." Available (in Spanish) at: https://www.cnmc.es/sites/default/files/3583977_4.pdf
[381] Telefónica, 22 February 2018, Telefónica and Orange sign a commercial wholesale agreement for fiber optic network. Available at: https://www.telefonica.com/en/web/press-office/-/telefonica-and-orange-sign-a-commercial-wholesale-agreement-for-fiber-optic-network
[382] European Commission, 2021, DESI Report 2020 – Electronic communications markets overview. Available at: https://digital-strategy.ec.europa.eu/en/library/2020-desi-report-electronic-communications-markets-overview-member-state-telecom-chapters
[383] European Commission, 10 December 2019, State aid SA.53925 (2019/N) - Broadband Scheme for NGA White and Grey Areas – Spain. Available at: https://ec.europa.eu/competition/state_aid/cases1/201952/282618_2120578_133_2.pdf
[384] Ministry of Economic Affairs and Digital Transformation, 2025 Digital Spain. Available at: https://portal.mineco.gob.es/en-us/ministerio/estrategias/Pages/00_Espana_Digital_2025.aspx

- Digitisation of Public Administrations: 50% of public services to be available through a mobile app by 2025.
- Digitisation of companies, with a focus on micro-SMEs and start-ups: 25% of the business volume of the SMEs to come from electronic commerce by 2025.
- Digitisation of sectors like Agri-food, Mobility, Health, Tourism, Commerce or Energy which could reduce CO2 emissions by 10% by 2025.
- Improve the attractiveness of the audio-visual platform: to increase audio-visual production by 30% by 2025.
- Push for a data economy: at least 25% of the companies to use Artificial Intelligence and Big Data by 2025. At the same time guaranteeing the security and privacy of the consumers.
- To draw a charter of guaranteed digital rights which would include labour, consumer, citizen, and business rights.

A key focus area of *Digital Spain 2025* is the provision of broadband speeds of at least 100 Mbps to the entire Spanish population by 2025. The Spanish government has now provided further detail on this goal in the form of the 'Plan for Connectivity and Digital Infrastructures and the Strategy to Promote 5G Technology.' The plan would receive €4.3 billion in public funding to be used to expand fibre-optic infrastructure to underserved areas and extend 5G coverage.[385]

In an interview, Diego Otero, Deputy Director of telco market analysis at CNMC highlighted the benefits of Spain's full-fibre strategy. These included building a future-proof fixed broadband technology to support the Digital transition and expand 5G coverage.[386] As of 2020, 73% of the total fixed broadband subscribers in Spain are on FTTH.

The *Digital Spain 2025* initiative builds upon *Spain's 5G National Plan 2018-2020* which was published in 2017.[387] The 5G plan reflects the common objectives of the EU Member States[388] and is based on four key actions that reflect the output of the public consultation.

- Radio spectrum management and planning – to secure necessary frequency bands for 5G services within relevant timeframes.
- Driving 5G technology – to establish network and service pilot projects aimed at engaging operators, equipment manufacturers and other industry players to develop 5G ecosystems and new business models. This also includes support of entrepreneurship and R&D and investment activity in the sector.
- Regulatory issues – to identify and develop suitable legal instruments, including spectrum regulations, that provide an "adequate and flexible legal framework" to promote 5G deployment.
- 5G Plan coordination and international cooperation – to develop the necessary governance framework, to continue international cooperation, support actions, and to continue 5G standardisation work.

[385] IEEE Technology Blog, 2 December 2020, Spain's plan to bring FTTH and 5G to its entire population. Available at: https://techblog.comsoc.org/2020/12/02/spains-plan-to-bring-ftth-and-5g-to-its-entire-population/
[386] Light Reading, 28 February 2020, Full-fiber strategy is achieving Gigabit Spain. Available at: https://www.lightreading.com/full-fiber-strategy-is-achieving-gigabit-spain/v/d-id/757879
[387] Ministry of Energy, Tourism and Digital Agenda, 2017, Spain's 5G National Plan 2018-2020. Available at: https://avancedigital.mineco.gob.es/5G/Documents/plan_nacional_5G_en.pdf
[388] As outlined within the Ministerial Declaration of Tallinn on making 5G a success for Europe: https://mmpi.gov.hr/UserDocsImages/arhiva/Ministerial-declaration-5G-final-signed.pdf

3.8.3.3 Pro-competition policies

The *General Telecommunications Law* (2014) is the primary piece of legislation that governs the telecoms sector in Spain. Key aspects of the Law are summarised below.[389]

- Shared use of infrastructure for the deployment of networks.
- Banning of preferential or exclusive rights.
- Recognition of broad rights of occupation over public domain.
- Simplification of administrative procedures – i.e. replacing authorisations and deployments of infrastructure with statements of compliance. Further, statement of compliance can also be excluded in case of technological innovation.
- Not all operators are required to fund the universal service but only those whose annual global gross income exceeds €100 million.
- Rights of users, including automatic termination of contracts at the end of the process of switching of operator with number porting; compensation in the event of delays or abuses in number portability; disconnection of services only upon users' request; right to receive the proof of contract in writing or another medium; and administrative approval of the contracts to also include administrative and judicial review of the standard terms and conditions contained in the contract.

The European Commission's 2018 directive on *European Electronic Communications Code* (EECC) has led to a need to revise the 2014 Act. The draft of the new *General Telecommunications Law* introduced in 2020 incorporates aspects of the Electronic Communications Code and was published for public consultation in September 2020.[390] The key aspects of the draft bill are highlighted below.[391]

- Expanding the scope of the electronic communications' regulation in Spain to include aspects related to telecommunications equipment, common telecommunications infrastructure in buildings, all uses of the public radio electric domain; and interpersonal communication services not based on numbering or messages – i.e. Over-the-Top (OTT) messaging.
- In light of the covid-19 pandemic the draft also puts an emphasis on providing universal service at affordable prices. For example, it states that all operators are to provide customers with a choice of service and the possibility of universal service.
- Focuses on transparency of contracts, limiting their duration, and for the first time also regulating the service packages.
- Emphasis on spectrum management to facilitate the deployment of 5G networks and other innovative wireless services. One of the potential reforms would be to have a minimum duration of 20 years for licenses associated with limitative use of spectrum.

[389] Lexology, 9 May 2014, Telecommunications Act 9/2014 of 9 May: the five major changes. Available at: https://www.lexology.com/library/detail.aspx?g=d6735ebb-bd1e-422a-a84e-5f61bd388ff2
[390] The Law Reviews, 3 February 2021, The Technology, Media and Telecommunications Review: Spain. Available at: https://thelawreviews.co.uk/title/the-technology-media-and-telecommunications-review/spain#footnote-012
[391] Ministry of Economic Affairs and Digital Transformation, 11 September 2020, "The government presents to a public hearing the Draft of the General Telecommunications Law." Available (in Spanish) at: https://www.mineco.gob.es/portal/site/mineco/menuitem.ac30f9268750bd56a0b0240e026041a0/?vgnextoid=bc02136f13c74710VgnVCM1000001d04140aRCRD&vgnextchannel=864e154527515310VgnVCM1000001d04140aRCRD

- Proposition of imposing administrative obligations, such as registration in the Registry of Operators and the obligation to observe certain security measures.

The new law is expected to be finalised and passed towards the end of 2021.[392]

Orange relied on the following strategies to support its FMC offering in Spain.[393]

- Fibre-sharing and Co-investment approach: massive deployment of fibre (FTTH) was underpinned by the approach of fibre-sharing and co-investment approach Vodafone, which also involved mobile network sharing.[394] Orange covered 14.8 million households with fibre by 2019 and has a target to cover 18.8 million by 2023.[395]

- Multi-brand strategy: It tailored its bundled and fixed-mobile offerings to different market segments under different sub-brands, to better compete in the market. Orange targets the premium market, with symmetric fibre broadband from 100Mbps to 1Gbps, fixed voice, IPTV, and mobile services. Its Jazztel sub-brand targets mid-market, and uses Orange uses its Amena sub-brand to target price-sensitive customers with low-cost mobile and fixed broadband offerings.

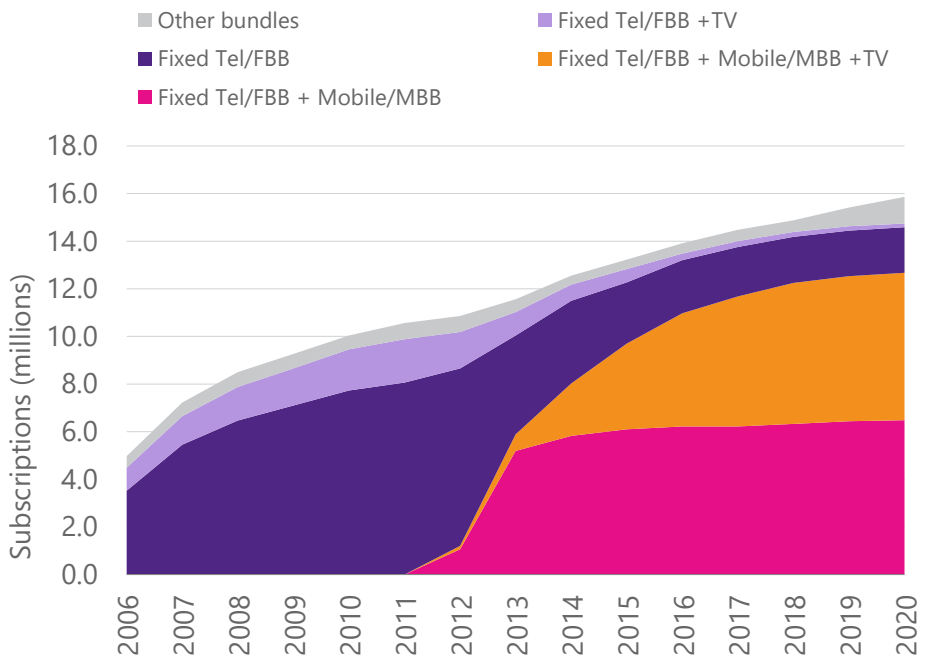
3.8.3.4 Provision and uptake of FMC bundles

Bundled offers continue to shape the broadband market in Spain. Convergent bundles account for more than 80% of the fixed broadband market and almost half of them are quintuple play.[396] In Q1 2019, more than 97% of the broadband lines were commercialised on a bundled basis. According to Eurobarometer, 57% of the respondents subscribed to fixed broadband service as a part of a service bundle, and 66% subscribed to mobile service as a part of a service bundle This is well above the EU average of 45% and 36% for fixed and mobile bundles respectively.[397]

Figure 3.14 below shows the total number of bundle subscriptions by type from 2006 onwards. There has been a significant growth in customer take-up of all bundle types, from 4.9 million in 2006 to 15.9 million in 2020, and a shift from fixed bundles to fixed-mobile bundles. Fixed-mobile bundles were first reported in 2012,[398] with 1.1 million fixed-mobile subscriptions in the first year; there were 6.5 million fixed-mobile subscriptions in 2020. Fixed-mobile subscriptions are now the most popular type of bundle, representing 40.9% of all bundle subscriptions, followed by fixed-mobile-TV subscriptions, which represent 39.1% of bundle subscriptions.

[392] Environment, Land and Resources, 2 February 2021, Spanish Public Law in 2021: 10 Things to Look Out For. Available at: https://www.globalelr.com/2021/02/spanish-public-law-in-2021-10-things-to-look-out-for/
[393] Verdict, 6 February 2020, Orange Spain's road to success with convergence as a growth engine. Available at: https://www.verdict.co.uk/orange-spain-convergence-growth-engine/
[394] Orange, 25 April 2019, Orange and Vodafone strengthen their mobile and fixed network sharing agreements in Spain, press release. Available at: https://www.orange.com/sites/orangecom/files/2020-06/2019%2004%2025%20PR%20Network%20sharing%20in%20Spain.pdf
[395] Verdict, 6 February 2020, Orange Spain's road to success with convergence as a growth engine.
[396] European Commission, 2021, DESI Report 2020 – Spain Telecom Chapter.
[397] Eurobarometer, June 2021, E-Communications in the Single Market. Available at: https://europa.eu/eurobarometer/surveys/detail/2232
[398] Based on available data from CNMC. 2012 appears to be the year uptake of fixed-mobile bundling was recorded in Spain rather than the year fixed-mobile bundling was launched.

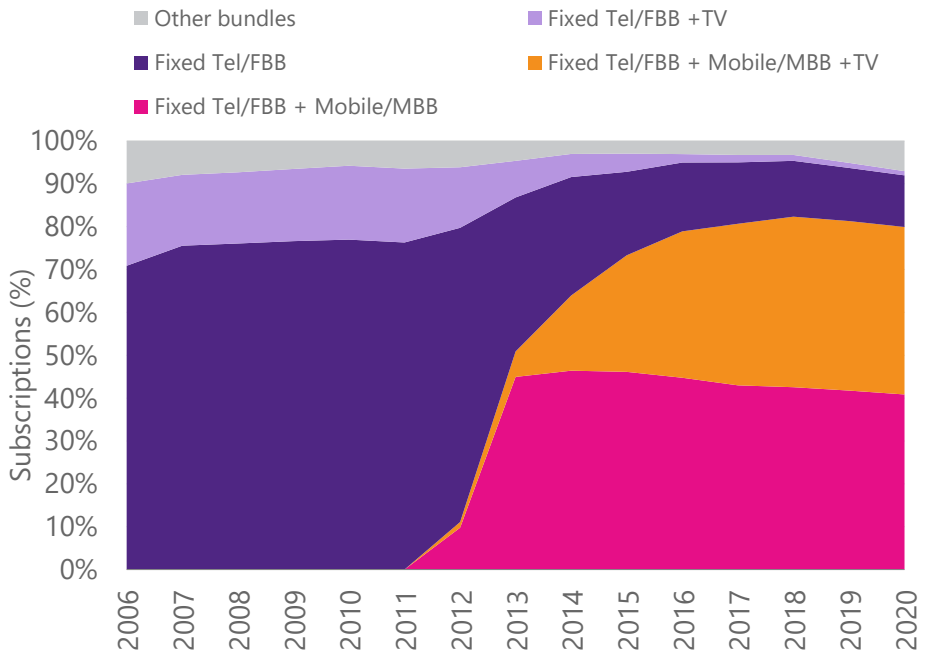
Figure 3.14: Uptake in bundled packages by type (million subscriptions), 2006-2020



Source: CNMC

Figure 3.15 illustrates how the proportion of bundled subscriptions has changed over time. It is clear that there has been a significant shift towards fixed-mobile bundles (with or without TV included) since their introduction in 2011. The proportion of fixed-mobile only bundles (without TV) peaked at 46.4% in 2013 and has since declined to 40.9% (there has however been a small growth in the absolute number of fixed-mobile only subscriptions over the period). There is no reported data on churn of fixed-mobile (or other) bundled subscriptions for Spain.

Figure 3.15: Uptake of bundles by type (percentage), 2006-2020



Source: CNMC

3.8.3.5 Retail pricing of FMC bundles

In Spain, three out of the four main mobile operators bundle fixed, mobile and TV services. Only Vodafone and Yoigo offer fixed-mobile only packages (excluding TV); though the extent that services are discounted depends on the choice of package and the number of lines. It is common for operators to offer an introductory discount (for example, 50% for first three months). Yet, operators tend not to make additional offers for existing customers subscribing to a second service with them.[399]

Movistar, the largest fixed-mobile operator, does not offer fixed-mobile only packages. All bundled subscriptions include TV services, and there are no simple discounts available for when existing subscribers (e.g., of mobile services) take out another Movistar service (e.g., fixed broadband subscription).

Similarly, Orange ES does not offer fixed-mobile packages to new or existing customers. New customers can subscriber to its triple-play, fibre-mobile-TV packages. Orange offers several different discounts to its existing (single-service) subscribers to encourage take-up of bundled offers. Whilst these include fibre and 5G mobile services, it also includes access to Orange's subscription TV service, and more expensive packages include access to additional sports, Netflix and Amazon Prime streaming services.

Vodafone offers mobile and fibre packages that provide a substantial discount compared to separate mobile and fibre subscriptions. For example, a 600 Mbps fibre (fixed-only) package is €30.99 and an unlimited 5G mobile package is €23.99 per month (includes TV subscription, unlimited downloads and quoted price includes 50% discount for first three months), whereas the equivalent fixed-mobile package is €44.99 per month (includes 50% discount for first three months).[400] However, service choice for fixed-mobile packages is more

[399] Based on review of retail offers from Spain's mobile network operators, reported as of 29/09/21.
[400] Vodafone ES fibre, mobile and fibre-mobile offers reported as of 29/09/21: https://www.vodafone.es/c/particulares/es/productos-y-servicios/movil/contrato/tarifas-contrato/, https://www.vodafone.es/c/particulares/es/productos-y-servicios/vodafone-one/, https://www.vodafone.es/c/particulares/es/productos-y-servicios/fibra-optica-adsl/

limited. For example, Vodafone's fibre-only plans offer top-line speed of 600 Mbps or above though the most common speed specified in fixed-mobile package is 300 Mbps. Similarly, a range of monthly usage allowances available to mobile-only subscriptions is not reflected in the Vodafone's three fixed-mobile offers.

The smallest operator, Yoigo, primarily offers fixed and mobile communications services, and its Agile TV subscription offering is not included as part of any packaged offer. Yoigo does offer fibre-mobile packages which include a fibre broadband connection, fixed voice and an option for the multiple mobile lines. The combined fibre-fixed-mobile package offers a modest discount compared with separate fibre-fixed and mobile packages if there is only one mobile line. However, a significant discount can be incurred if a fibre-fixed-mobile subscriber has multiple mobile SIMs, as each additional mobile line costs only €3 per month.

3.8.3.6 Appraisal

Fixed mobile convergence in Spain has been driven by market consolidation and to an extent by government policy and regulatory measures.

Historically the Spanish market has been characterised by a large number of regional cable operators. Over the last 5-10 years, there have been a series of mergers and acquisitions involving MNOs and major cable players. These MNOs and operators have sought to achieve cost savings and operational efficiency, as well as to improve their competitive positioning in the market, particularly with regard to multi-play packages combining mobile, broadband and TV services.

This wave of consolidation has meant that the market is now dominated by several telecom conglomerates, each with its own fixed, mobile and pay-TV (cable or IPTV subscription) operations. As a result, the main network operators have been able to offer fixed-mobile and other bundled services, a trend which has been replicated by MVNO and ISP resellers. This is reflected in the high proportion of quadruple or quintuple offers, which account for approximately 40% of the market. Further, several operators such as Orange have adopted a multi-brand strategy – i.e. providing tailored fixed-mobile and bundled services to different price segments – which has also contributed to the high fixed-mobile penetration observed in Spain.

Government policy has also helped deliver extensive fibre deployment and supported infrastructure sharing. Further, a ban on exclusive rights and recognition of broad rights of occupation have allowed operators access to other operators' mobile and fixed infrastructure. A simplified regulatory mechanism that accepted compliance statements in place authorisations have additionally eased the convergence process. Due to the focus of public policies and private initiatives on infrastructure sharing, network operators have developed co-investment and fibre-sharing strategies to cost-effectively deploy their infrastructure.

4 Influence of tech giants

4.1 Introduction

Tech giants (or "big tech" companies) include a variety of businesses ranging from hyperscale cloud providers to larger over-the-top (OTT) service providers. This section considers actions taken by tech giants, their influence and their effect on the mobile value chain (including MNOs). Over the past decade the presence of these players has become much more visible in the provision of services to end users, including those using mobile networks. There are many positives resulting from the presence of tech giants who can deliver solutions to both end users and to mobile operators. Tech giants are well placed to deliver solutions that can drive increased service scope, agility, efficiency and lower costs. However, there have also been concerns raised about tech giants in respect of both market influence and the potential for harms under some conditions. The key to ensuring that the influence of tech giants is beneficial is to create conditions that reduce the risk of more negative consequences of their presence playing out.

4.2 Definition

A variety of terms are used for tech giants and below are set out some definitions for this report.

Hyperscale: Key hyperscale players are Amazon Web Services (AWS), Google Cloud Platform (GCP), Microsoft Azure and Alibaba. While there is no clear definition of a hyperscale provider it is usually a business that provides cloud computing, storage and networking on a very large scale. Other players like Facebook and Apple are sometimes also referred to as hyperscale providers, however, they are predominantly retail suppliers (Apple does provide storage to users as part of its retail bundles).

OTT service providers: These players can vary in size from being small to very large (e.g., at the large end Facebook, Apple, Disney). They are businesses that deliver services (e.g., video) to users over an IP network (including mobile). Some very large OTT providers (e.g., Amazon Prime video) might also be considered hyperscale. OTT service providers also encompass a wide range of businesses that deliver services to the enterprise segment (e.g., Salesforce, Oracle).

Another term used is "big tech" and this is generally understood to include a group of companies like Amazon, Apple, Google, Facebook and Microsoft.

4.3 Tech giants findings

The key findings of our research on tech giants are:

- These players are undoubtably present in the mobile value chain and are having increasing interaction with both network providers and directly with consumers, much of which is delivering positive results.
  - For content and applications there is an increasing level of provision to consumers on mobile devices by OTT service providers.
  - Specialist technology and hyperscale providers are already playing a role in provision of mobile network services as network functions are virtualised (e.g., 5G core, Open RAN) and involvement in Mobile Access Edge Computing (MEC).

- Tech giants (and many other technology providers) are also exploring the potential to supply to Mobile Private Networks (MPNs).

We do not see a near term structural shift taking place between tech giants and MNOs – for example, the entire network business of MNOs moving to tech giants. However, we do see that tech giants will provide more network and other services to MNOs over the next few years. These services are most likely to comprise, for example, Infrastructure as a Service (IaaS) and Software as a Service (SaaS). Technology suppliers are also providing Network as a Service (NaaS) and Communications Platform as a Service (CPaaS) capability. So far, the primary users of NaaS are enterprises who do not own (or want to own) a network of their own. Whether tech giants will end up being full NaaS providers to MNOs is difficult to judge at this time, but there is an opportunity for MNOs or other wholesale operators to provide NaaS to MVNOs. Nokia, for example is considering how this might play out and the opportunity exists for tech giants to do likewise.

Where tech giants have ventured into connectivity it has been to drive this from a low base (e.g., in developing markets) and/or to drive more traffic to their services. We did not see any significant evidence that tech giants intend to move into being more general access network providers (although with developments like Open RAN, Mavenir and others, not generally seen as tech giants, will become more visible).

5G MPNs, where the combination of open networks (e.g., Open RAN) together with the ability to run a 5G standalone core on cloud native infrastructure, might open the door (provided suitable spectrum can be obtained) to new enterprise service providers, who rely totally on others to provide their networks (e.g., NaaS). While these business models are conceptually possible, concrete examples that show the approach works have yet to emerge. This is a potential opportunity for tech giants and others (e.g., systems integrators).

In the consumer market Google has gone down the road of becoming an MVNO with Project Fi (now Google Fi). The most capable versions of Fi use specific capabilities in Google's mobile devices, the Android OS and more recently eSIM capability. So far, there have not been similar moves by Apple.

Tech giants are also increasing their role in mobile (and other network) back-office functions like OSS/BSS. Taking these functions into the cloud allows for the retirement of expensive legacy systems, integration of OSS/BSS capability across multiple network platforms and can deliver advantages in flexibility and agility to MNOs.

For consumer services, OTT service providers have an increasing affinity with consumers built on content and applications, which limits the ability of MNOs to develop new service revenues by creating these services for themselves. The trend among MNOs is, where possible, to work with these players (e.g., by bundling their services into mobile subscriptions). We expect these trends to continue. However, the increasing share of OTT service provision creates increased dependencies on these suppliers and raises security, resilience and privacy risks, which MNOs increasingly having to consider. Governments and regulatory authorities are likewise considering these issues.

Regulatory responses

There are multiple drivers for regulatory responses to tech giants including (depending on the type of player):

- Concerns about their ability to exert market power (e.g., on search engines).
- Dealing with illegal or harmful content.
- Security and privacy issues.
- Sovereignty.

- Network resilience.

Many jurisdictions are now considering or acting on these concerns and other policy/regulatory issues, but this needs to be done carefully to ensure that the beneficial aspects of tech giants are not lost. Alignment around regulatory issues is starting to occur but there is little global consistency at present on the approach to regulation of tech giants. Reasons for might this include:

- These players are international or global in scope and want to retain a high level of ability to self-regulate to allow the minimum amount of variation between operations in different countries.
- Up to now they have largely operated in an ex-post environment and are likely to wish to retain this position as far as possible.
- Ex-ante measures create the possibility of multiple approaches from different jurisdictions, which require different compliance responses.
- Unlike the telecommunications industry they have not developed in an environment where there has been harmonisation driven by industry standards (e.g. around interoperability).

4.4 Tech giants and the UK

Tech giants are well established in the UK. More specifically:

- Hyperscale players have a presence in the UK (e.g., Microsoft Azure has been offering services from UK data centres since 2016, as has AWS). They are actively developing their businesses including potential business with MNOs and others in the mobile sector as 5G developments progress. Examples of hyperscale involvement include:
  - AWS and Vodafone UK with AWS Wavelength, providing MEC services, and
  - O2's partnership with Microsoft Azure for MEC within private 5G networks.

Examples of policy/regulatory responses in the UK include:

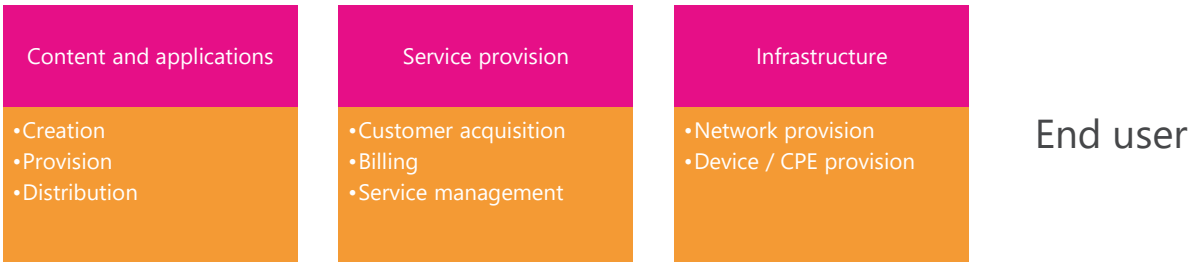
- Online harms – Online Safety Bill – This is aimed at creating a new regulatory regime to address illegal and harmful content online, with the aim of preventing harm to individuals in the United Kingdom. It:
  - Imposes duties of care in relation to illegal content and content that is harmful to children.
  - Imposes duties on providers in relation to the protection of users' rights to freedom of expression and privacy.
  - Confers powers on Ofcom to oversee and enforce the new regulatory regime.
- The government has also consulted on a new pro-competition regime for digital markets. The Plan for Digital Regulation sets out the government's overall vision for governing digital technologies including new principles to guide design and implement the regulation for digital technologies. Enabling more active innovation is a key driver.

However, at present there are no substantive plans to consider new policy or regulation in respect of the role tech giants are likely to play in the provision of mobile services as MNOs upgrade and expand their networks.

4.5 Mobile value chain

Plum has taken a simplified approach to the mobile value chain showing three key aspects of value for the supply of mobile services.

Figure 4.1: Mobile value chain



Within each of the three broad categories above there are several supply components. For example, infrastructure includes:

- Physical infrastructure access (e.g., RAN formed of passive and active elements).
- Core networks and interconnecting infrastructure (e.g., backhaul and backbone).

We have not attempted to map out a complete supply player map, which could include entities like MNOs, tower providers, service wholesalers and so on.

There are several other things required for provision of mobile infrastructure including access to:

- Radio spectrum (for RAN and backhaul).
- Numbering resources (including mobile network codes).
- Facilities (e.g., land, towers) via the UK Electronic Communications Code.

Other regulatory issues comprise things like roaming agreements, MVNO agreements and provision of wholesale services.

Focusing on the influence of tech giants and OTT service providers, the most obvious entry point has been in content and applications – the development, hosting and operation of on-line services provided to consumers and enterprises. There are numerous examples including search engines (e.g., Google, Bing), communications and messaging platforms (e.g., Facebook messenger, WhatsApp, etc), content platforms (e.g., Netflix, Apple TV), enterprise platforms (e.g., Salesforce, Xero), trading platforms (e.g., eBay, Etsy, Rakuten), and many other examples (e.g., Airbnb, Uber). Google and Apple also hold key positions in the provision of devices and Operating Systems (OS).

Tech giants are also set to play an increasing role in the provision and operation of networks, often through larger scale cloud service providers, which include AWS, Azure and Google Cloud. Technology players are also increasingly present in aspects of service provision as the likes of Amdocs and Netcracker work more closely with big tech firms like AWS and Azure to move their services to cloud solutions. Key here are operation support system (OSS) and business support system (BSS) capabilities[401,402] but other aspects like AI, customer

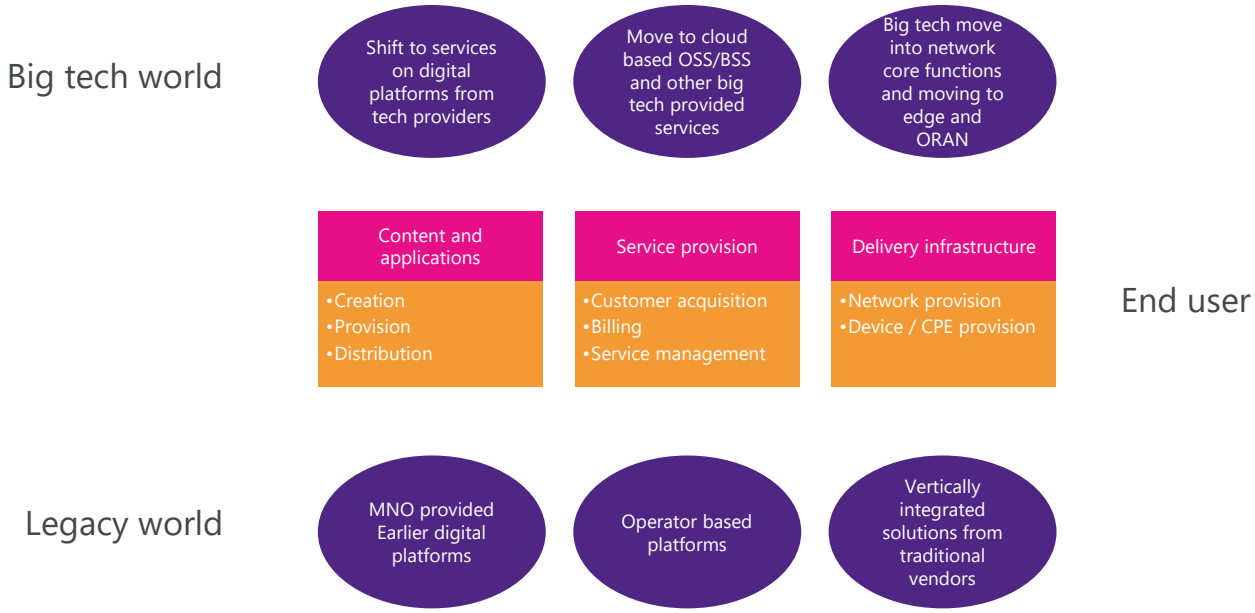
[401] Ericsson, November 2020, The journey to a cloud BSS. Available at: https://www.ericsson.com/en/blog/2020/11/the-journey-to-a-cloud-bss
[402] Comarch, 2021, Cloud Transformation: Flexible Transfer of Systems to the Cloud for Telecoms. Available at: https://www.comarch.com/telecommunications/services/cloud-transformation/

management and data mining are relevant. Moves in this area potentially increase the quality and agility of service provision and enable more rapid development and economies of scale to be leveraged. For example, the use of software to create new services, to launch new products quicker by avoiding changes required to legacy OSS/BSS systems and reduce costs.

Tech giant involvement in mobile infrastructure has been happening for some time and is expected to increase. The use of network virtualisation has opened the opportunity for these providers to deliver carrier-grade mobile packet core and this is developing into 5G core. New opportunities arise with open networking developments, and especially Open RAN. The use of edge cloud and in a 5G environment Mobile-access Edge Computing (MEC) is also seen as a key growth area for tech giants.

Figure 4.2 illustrates the above opportunities for big tech.

Figure 4.2: Mobile value chain and big tech



4.6 Big tech infrastructure investments

4.6.1 Data centre investment

Distributed data centre capacity is essential for tech giants wanting to play in the mobile field. Below are some examples of data centre investments. While not all directly relevant to mobile, they illustrate the scale of investment being undertaken.

Amazon Web Services (AWS), Microsoft and Google now collectively account for more than 50% of the world's major data centres.[403] The increased demand for digital services and a shift to remote working, supported by cloud facilities, during the COVID-19 pandemic has driven demand for data centre capacity, with data centre investment reaching US$37 billion and more than 100 new hyperscale data centres being built in 2020.[404]

[403] CRN, 27 January 2021, AWS, Google, Microsoft are taking over the data centre market. Available at: https://www.crn.com/news/data-center/aws-google-microsoft-are-taking-over-the-data-center
[404] DCD, 27 January 2021, Microsoft, Amazon, and Google operate half the world's 600 hyperscale data centers. Available at: https://www.datacenterdynamics.com/en/news/microsoft-amazon-and-google-operate-half-the-worlds-600-hyperscale-data-centers/

AWS, Microsoft, Google and Facebook are reported to be the largest investors in data centres in Southeast Asia, with capex budgets far outstripping other operators in the market. Apple, Alibaba and Tencent were the second largest data centre investors in the region.[405] A similar picture is observed in Europe and North America where AWS, Microsoft, Google and Facebook have all made significant investments, some of which are discussed below.

AWS is currently collaborating with a Spanish communications and entertainment group NOS in Portugal to provide on-site equipment that connects via local 5G-ready networks to the AWS services and then offers high data processing capacity to local businesses.[406] The project, known as AWS Outposts[407], will enable companies to expedite IT upgrades and provide tailored cloud solutions to benefit from better data storage, flexible service, cost reduction and scalability.

Microsoft and Facebook have also announced plans to launch regional data centres. Increased data centre investment has driven big tech's expansion into supporting infrastructure.

4.6.2 International backbone investment

Hyperscale and large scale OTT providers are increasing investment in telecoms infrastructure and connectivity projects around the world.[408] Hyperscalers such as Google and Facebook have a vested interest in supporting the availability of high-speed broadband for users because of high bandwidth demand (from inter-data centre content distribution and cloud computing) to support their services. Between 2013 and 2017, the international bandwidth of the tech giants grew by 80% CAGR and was almost half of the total international bandwidth consumed in 2017. [409] As a result, these players have increasingly invested in international backbone whilst relying on traditional fixed and mobile network infrastructure for last-mile delivery to customers.

Google, Facebook and Microsoft are the largest big tech investors in subsea cables.[410] As of 2019, there were more than 400 undersea cables in service around the world, constituting 1.1 million kilometres. Google holds 10% of this subsea cable share (around 100,000 kilometres of these cables) which are either fully owned or co-owned with other subsea cable and fixed infrastructure operators and other technology companies. Initially (10 or more years ago) these players co-owned subsea investments with network operators like Telstra. More recently this mode of co-ownership has reduced. Examples of Google's subsea cable projects are highlighted below:[411]

- **Curie**, the first fully Google-owned international subsea cable runs from Los Angeles, California down the Pacific coast to Valparaíso, about 120km northwest of Chile's capital, Santiago. Its total length is 10,000 km.

[405] Channel Asia, 4 June 2021, Hyperscale cloud providers ramp up data centre investment. Available at: https://www.channelasia.tech/article/688888/hyperscale-cloud-providers-ramp-up-data-centre-investment/
[406] DataCentre, 27 October 2020, NOS to bring AWS to Portugal, Spain. Available at: https://datacentremagazine.com/networking/nos-bring-aws-portugal-spain
[407] AWS Outposts is a fully managed service that offers the same AWS infrastructure, AWS services, APIs, and tools to virtually any data centre, co-location space, or on-premises facility. See: https://aws.amazon.com/outposts/
[408] ITU-D, 2020, Economic impact of OTTs on the national telecommunication/ICT markets, ITU-D Study Groups, study period 2018-2021. https://www.itu.int/en/myitu/Publications/2020/07/09/15/47/Economic-Impact-of-OTTs-on-National-Telecommunication-and-ICT-Markets
[409] Delta Partners, 2019, From telcos to tech-cos. Available at: https://deltapartnersgroup.com/2019/03/05/from-telcos-to-tech-cos/
[410] Wired, 18 November 2018, Google and Facebook are gobbling up the internet's subsea cables. Available at: https://www.wired.co.uk/article/subsea-cables-google-facebook
[411] VentureBeat, 24 April 2019, How Google is building its huge subsea cable infrastructure. Available at: https://venturebeat.com/2019/04/24/how-google-is-building-its-huge-subsea-cable-infrastructure/

- **Dunant,** announced in 2020, is Google's second self-owned international subsea cable. It is 6,400km in length and stretches from Virginia Beach in the USA to Saint-Hilaire-de-Riez, France. Google announced that Dunant was ready for operations in March 2021.[412]

- **Havfrue/AEC-2** is co-owned by Aqua Comms, Bulk Infrastructure, Facebook, and Google. It spans over 7200 km from Wall Township, New Jersey to Western Europe. It has landing points in Ireland, Denmark, and Norway. It began operations in December 2020.[413]

- **Pacific Light Cable Network (PLCN)** is a project between Google, Facebook, and Pacific Light Data Communication Co. Ltd. It was expected to be completed by the third quarter of 2019, however the project is experiencing some delays. [414] Its landing points are in Hong Kong, Philippines, Taiwan and California. Both Facebook and Google have decided to not deploy the Hong Kong and China sections in the light of the recent political tensions. [415]

In addition to its backbone co-investments with Google (Havfrue/AEC-2 and PLCN), Facebook has launched other projects with telecom partners. These include:

- **Facebook's Telecom Infrastructure Project (TIP)**, which was launched with Intel, Nokia, Deutsche Telekom, and SK Telecom amongst other partners in 2016. TIP disaggregates the network components that are traditionally bundled together and vendor specific.[416]

- **Facebook MAREA** is a high-capacity transatlantic cable connecting the US and Spain. It is funded by Facebook, Microsoft, and Telxius (subsidiary of the Spanish telecommunications giant Telefónica). It completed construction in September 2017.[417]

It is expected that tech giants will continue to make investments in this type of infrastructure as they expand networks due to increasing data demand and to ensure a high level of security and resilience on key data centre links and connections to major in country networks. They will take a bigger share of international capacity as a result. However, increasing subsea high-capacity bandwidth also needs to be balanced with investments in data centres to ensure that traffic and other parameters like latency are optimised in traffic flows.

4.7 Big tech players as service providers

There have been several attempts by big tech companies to launch themselves as communications service providers. It is important to understand the motivations for specific service launches, which usually link to driving traffic to or otherwise increasing dependence on a specific player. Some of these initiatives should be viewed as experiments aimed at attempting to enter new markets and develop new customer relationships.

- **Google Fiber**[418] First announced in 2010, its objective was to provide gigabit connectivity using FTTP infrastructure to the towns and cities of US. The internet is delivered through Webpass, an ISP provider

[412] 9TO5Google, 3 February 2021, Google Dunant trans-Atlantic cable. Available at: https://9to5google.com/2021/02/03/google-dunant-undersea-fiber-cable/
[413] Capacity, 3 December 2020, Aqua Comms' AEC-2 cable goes live. Available at: https://www.capacitymedia.com/articles/3827118/aqua-comms-aec-2-cable-goes-live
[414] Tech Crunch, 6 February 2020, Google and Facebook turn their backs on undersea cable to China. Available at: https://techcrunch.com/2020/02/06/google-and-facebook-turn-their-backs-on-undersea-cable-to-china/
[415] Tech Crunch, 6 February 2020, Google and Facebook turn their backs on undersea cable to China. Available at: https://techcrunch.com/2020/02/06/google-and-facebook-turn-their-backs-on-undersea-cable-to-china/
[416] Telecom Infra Project, 22 February 2016, Facebook: Partnering to build the Telecom Infra Project. Available at: https://telecominfraproject.com/facebook-partnering-to-build-the-telecom-infra-project/
[417] Data Centre Knowledge, 22 September 2017, Facebook and Microsoft's High-Capacity Submarine Cable to Europe Complete. Available at: https://www.datacenterknowledge.com/networks/facebook-and-microsoft-s-high-capacity-submarine-cable-europe-complete
[418] Further information on Google Fiber available: https://fiber.google.com/

that Alphabet bought in 2016. Despite its promise, Google Fiber's market performance has not been as good and the project has been scaled back.[419,420]

- **Express Wi-Fi**[421] Launched by Facebook in 2016 to provide wireless connectivity via public Wi-Fi hot spots in areas across the world that have no or limited connectivity. It is currently available in the most populous cities of ten countries in Africa as well as countries in Asia, and South America, though most deployments tend to be restricted to capital cities only.[422]

- **Google Fi:** an MVNO launched by Google in 2016 and hosted on Sprint, T-Mobile and US Cellular networks and originally available on Nexus phones. However, it is now available on most Android and iPhone mobile devices. Fi now supports physical and eSIM implementations. It seeks to provide consistent service availability through an intelligent switch between the host's carrier networks and Wi-Fi. The switching available depends on the device used and its capability. Phones such as Pixel, Moto G7, Moto G6, LG G7 ThinQ, LG V35 ThinQ, and Android One Moto X4 support connection to multiple cellular networks.[423] Other devices cannot support multiple cellular networks but still support intelligent switching between a mobile network and Wi-Fi. Other features include rebates on unused data,[424] free international roaming, access to 2 million secure Wi-Fi hotspots and data protection through a Google VPN.[425] Customer reviews indicate its offer of paying only for data used is viewed favourably, which results in potentially lower monthly bills. However, there have been some complaints regarding its call quality.[426]

- In Asia, several conglomerates have successfully launched themselves as mobile network operators, leveraging their positions in technology and media markets. A notable example is the Rakuten Group in Japan, which initially entered the Japanese market as an MVNO and launched as a full MNO in 2018 (discussed in Section 2.5, HQN Japan case study).

While there are several examples of how big tech is playing in mobile service provision, this has not been a major thrust of their businesses (except for activity in the US). It involves creating businesses that potentially require licensing under national telecoms regulatory regimes, and compliance with other regulation and legislation (e.g., security). Big tech players seem more inclined to participate through playing an increasing role in the mobile value chain enabled by virtualisation concepts and edge computing, in addition to continuing with their upstream content and applications business.

4.8 Increasing role of big tech in mobile networks

Developments in telecommunications network architectures have opened the way for big tech participation as Network Function Virtualisation (NFV),[427] Software Defined Networking (SDN) and edge computing become more prevalent. These concepts are increasingly becoming a part of the network design and are becoming embedded in the 3GPP and ETSI standards.

A vision of future networks could be very different to the legacy mobile infrastructure in use today. The traditional suppliers to MNOs (e.g., Nokia, Ericsson) are being supplemented by providers of software and computing capability that support SDN, NFV and Edge, including hyperscale players like Azure and AWS.

[419] IT Pro, 2 January 2020, What is Google Fiber. Available at: https://www.itpro.co.uk/infrastructure/network-internet/354446/what-is-google-fiber
[420] CNET, 5 March 2021, Whatever happened to Google Fiber? Available at: https://www.cnet.com/home/internet/google-fiber-explained/
[421] Further information on Facebook Express Wi-Fi is provided via: https://expresswifi.fb.com/
[422] TechTarget, last updated October 2018, Express Wi-Fi. Available at: https://whatis.techtarget.com/definition/Express-Wi-Fi
[423] Questions about Google Fi. Available at https://fi.google.com/about/faq/
[424] Tom's guide, 18 October 2021, What is Google Fi, and is it worth it? https://www.tomsguide.com/uk/us/project-fi-faq,review-4530.html
[425] Fierce Wireless, 28 November 2018, Google goes all-in on MVNO. Available at: https://www.fiercewireless.com/wireless/google-goes-all-mvno
[426] Tom's guide, 18 November 2021, What is Google Fi, and is it worth it? https://www.tomsguide.com/uk/us/project-fi-faq,review-4530.html
[427] ETSI, 2018 Q2, What is NFV? Available at: https://www.etsi.org/images/files/etsitechnologyleaflets/networkfunctionsvirtualization.pdf

An example of a major big tech play in a network operator is AT&T's use of Microsoft Cloud for its 5G network using Microsoft Azure technologies.[428,429] AT&T claims that making this move will allow it to develop a more flexible and scalable service model that will allow it to reduce infrastructure and development costs.

SDN allows different virtual networks to be defined independently of each other with strong security controls around them, and strong separation even though they are running on the same physical infrastructure. Network hardware is usually generic in nature and is itself configured in software allowing for economies of scale both in the hardware design and remote management. SDN and NFV play a key role in concepts like "slicing", which allow greater flexibility for network and service provision.

Open networking concepts are also being adopted to allow development of more specialist network capability and to improve supply chain robustness for MNOs. The most mentioned example is Open RAN. Again, big tech is expected to play a key role here.

SDN and NFV are already well-established plays and below we consider in more detail developments around Edge computing and Open RAN.

4.8.1 Edge technologies

Edge computing refers to a cloud-based IT service environment located at the edge of a network. It is often a distributed, open IT architecture depending on decentralised processing power. In Edge applications, data is processed by the device itself or by a computer or server nearby (e.g., in the cellular base station). The proximity of Edge can have significant benefits both in terms of speed (latency and bandwidth) and overall network efficiency. Edge computing is an enabler of many mobile computing and Internet of Things (IoT) technologies.

Specifically in the context of 5G networks, Multi-access Edge Computing (MEC) is a technology aiming to satisfy the requirements of high-bandwidth and low-latency applications which operate at the edge of the network. MEC is based on the convergence of IT and telecommunications networking. Key benefits are reduced network congestion and improved performance for low-latency applications. MEC also includes workloads running on customer premise equipment and other points of presence at the customer site.

Providers of Edge are likely to be multiple combinations of the traditional MNOs and system vendors, together with cloud operators such as Google, AWS etc. Edge potentially enables many new use-cases such as IoT, V2X, AR and VR, remote medicine, etc, which require high performance network capabilities.

Examples of Edge developments include:

- **AWS Edge:** AWS Edge[430] provides data processing, analysis, and storage as close to the network endpoint as necessary. AWS Edge facilities can be deployed to locations outside AWS data centres and be deployed on MNO infrastructure and devices. Use cases supported include content delivery networking, network traffic acceleration and provision of low-latency services.

  For example, Vodafone is an early adopter of AWS Edge – Using AWS Wavelength it is possible to build applications that serve end users with low latency performance. AWS Wavelength will be enabled to provide MEC services at the Edge of Vodafone's mobile network in Europe to support IoT and other

[428] Microsoft, 2021, Azure for operators. Available at: https://azure.microsoft.com/en-us/industries/telecommunications/#overview
[429] Microsoft, 30 June 2021, AT&T to run its mobility network on Microsoft's Azure for Operators cloud, delivering cost-efficient 5G services at scale. Available at: 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/#:~:text=AT%26T%20to%20run%20its%20mobility%20network%20on%20Microsoft%E2%80%99s,grow%20its%20telecom%20flagship%20offering%2C%20Azure%20for%20Operators
[430] IDC, December 2020, AWS at the Edge: A Cloud Without Boundaries. Available at: https://d1.awsstatic.com/IoT/IDC-AWS-at-the-Edge-White-Paper.pdf

applications. To start with, the services will be aimed at enterprise customers and rolled out in the UK (already launched) and Germany.

- **Azure private multi-access edge compute (MEC):** Azure MEC[431] is designed to offer high-performance low-latency solutions for 5G mobile networks. It is aimed at provision of services for enterprises and targeted at several industries including manufacturing, healthcare, transport, and retail. Microsoft is working with network operators and systems integrators to provide edge capability. Network operator partners include AT&T, Etisalat, NTT, SKT, Telefonica.[432]

  For example, Singtel has partnered with Microsoft to provide 5G Edge computing on Microsoft Azure. The platform will provide access to the Azure stack, which will allow enterprise customers to support low-latency services such as VR, AR, self-driving vehicles and robots. Singtel is also understood to be considering extension of its MEC capability to other cloud platforms.

Although a considerable level of activity is developing around Edge and there are case studies emerging for 5G and MEC, it is still early in its lifecycle. Activity at present is largely confined to early movers and for MEC concentrated in the enterprise segment. Big tech is playing a key role in the alliances being established for development and delivery. Drivers for accelerating adoption will be the needed to roll out more advanced 4G and 5G solutions – the development of private enterprise and industrial networks and the desire for greater flexibility with provision of network functions.

4.8.2 Open RAN

The virtualisation technologies which have been developed since the introduction of 4G/LTE have opened many potential new methods for mobile telco system implementation and deployment. While these technologies are readily applied to system core functions, which are in most cases generic IT use cases, they can also be applied to the more specialised functions at the edge of the network where it interacts with user devices - the Radio Access Network (RAN). These specialised functions have until now required dedicated hardware devices which have been the preserve of the main equipment manufacturers (e.g., Ericsson, Nokia, Huawei etc.) and have been proprietary to those vendors requiring that the rest of the system be obtained from that vendor.

The newer technologies allow for the disintermediation of this position through two main opportunities. Firstly, many of the specialised functions of the RAN are now realisable in software on general purpose servers (there are several architectural options for the provision of COTS servers (i.e., general-purpose servers) to run Central Unit (CU) and Distributed Unit (DU) functionality including in MNOs own data centres (including at network edge) as well as in technology provider data centres (e.g., hyperscalers). Once implemented this provides for the second opportunity where the integration of these more generalised components has fewer dependencies on the vendor, thus allowing for increased flexibility and competition between vendor offerings. This permits a more modular approach to the RAN. An initiative adopting this approach is Open RAN, which is implemented on general purpose platforms with open interfaces between software defined functions. Big tech players, as a result, are looking to obtain a share of the OpenRAN market.

Open RAN allows operators to operate flexibly and to customise the network as needed both geographically, and potentially on a demand basis, and so has the potential to create cost efficiencies. Reducing the specialised nature of the infrastructure significantly reduces the barriers to market entry of potential new equipment providers. It will also allow multiple vendors to deploy their technology on the network, thereby enabling competition and reducing costs. Examples of big tech input to OpenRAN initiatives include:

[431] Azure, 16 June 2021, Unlocking the enterprise opportunity with 5G, edge compute, and cloud. Available at: https://azure.microsoft.com/en-us/blog/unlocking-the-enterprise-opportunity-with-5g-edge-compute-and-cloud/
[432] Microsoft, 21 June 2021, Azure private multi-access edge compute partner solutions. Available at: https://docs.microsoft.com/en-us/azure/private-multi-access-edge-compute-mec/partner-programs

- Dish and AWS are building a cloud-based, 5G Open RAN Network.[433] Dish will be the first standalone 5G Open RAN in the US. In addition to Open RAN, Dish will use other cloud native telco platform capabilities from AWS including for OSS and BSS capabilities.

- Vodafone has selected key partners for Open RAN deployment including Dell, NEC, Samsung, and others to build on the work done at Vodafone's Open RAN laboratory at Newbury.[434] Vodafone will initially focus on 2,500 sites in the UK to deploy Open RAN.

- Rakuten in Japan is collaborating with Fujitsu and NEC to promote Open RAN solutions.[435] Rakuten and Fujitsu already collaborate on providing RAN for the Rakuten network in Japan. Rakuten is also working with 1&1 AG in Germany to build a mobile network based on a cloud architecture including a fully virtualised cloud native Open RAN network.[436]

- Mavenir, a network software provider specialising in Open RAN and other network solutions is supporting deployment and integration of cloud native telecoms network functions with telecommunications infrastructure on AWS.[437] Mavenir has also developed next generation RAN Intelligent Controller (RIC) to allow enhanced Open RAN configurability and performance. Mavenir has worked with Vodafone on the UK's first live Open RAN site in Wales.[438] The company has also opened a new development centre for Open RAN radio software located at Swindon.[439]

- Google has partnered with Ericsson on Open RAN initiatives.[440] It has done a similar collaboration with Nokia on Open RAN, cloud RAN and Edge initiatives.[441] Similar collaborations exist with AWS and others.

As with Edge, there is a considerable level of activity around Open RAN, and this is increasing as early deployments are contracted. Technology players including big tech and others like Mavenir and Parallel Wireless already appear to be active. However, there is a long way to go with the deployment of Open RAN solutions and it will take several years for an extensive footprint of Open RAN to appear in established mainstream operators. It remains at an early stage of development and needs time to move to being a more robust part of the ecosystem as solutions become more powerful and better integrated into connectivity solutions.[442] For MPN deployments and new mobile entrants it is a potentially different story, with Open RAN and other cloud-based networking elements providing faster and more flexible market entry.

[433] Amazon, 21 April 2021, DISH and AWS Form Strategic Collaboration to Reinvent 5G Connectivity and Innovation. Available at: https://press.aboutamazon.com/news-releases/news-release-details/dish-and-aws-form-strategic-collaboration-reinvent-5g
[434] Vodafone, 14 June 2021, Vodafone selects key partners to build Europe's first commercial Open RAN network. Available at: https://www.vodafone.com/news/press-release/vodafone-europe-first-commercial-open-ran-network
[435] RCR Wireless, 18 May 2021, Rakuten Mobile inks O-RAN agreements with Fujitsu, NEC. Available at: https://www.rcrwireless.com/20210518/open_ran/rakuten-mobile-inks-oran-agreement-with-fujitsu-nec
[436] RCR Wireless, 5 August 2021, Germany fourth's mobile network will be Open RAN-based, built by Rakuten. Available at: https://www.rcrwireless.com/20210805/open_ran/germa-telco-selects-rakuten-oran-deployment
[437] Mavenir, 27 May 2021, Mavenir to Deliver Cloud-Based 5G Solutions on AWS. Available at: https://www.mavenir.com/press-releases/mavenir-to-deliver-cloud-based-5g-solutions-on-aws/
[438] Mavenir supports Vodafone in live Open RAN network for rural coverage in the UK. Available at https://www.mavenir.com/press-releases/mavenir-supports-vodafone-in-live-openran-network-for-rural-coverage-in-the-uk/
[439] Mavenir Opens a New Development Centre for Open RAN Radio Software in UK. Available at https://www.mavenir.com/press-releases/mavenir-opens-a-new-development-centre-for-open-ran-radio-software-in-uk/
[440] Techradar.pro, 2 July 2021, Google furthers telco push with O-RAN Alliance and Ericsson 5G partnerships. Available at: https://www.techradar.com/uk/news/google-furthers-telco-push-with-o-ran-alliance-and-ericsson-5g-partnerships
[441] Nokia, 15 March 2021, Nokia and Google Cloud partner to develop new, cloud-based 5G radio solutions. Available at: https://www.nokia.com/about-us/news/releases/2021/03/15/nokia-and-google-cloud-partner-to-develop-new-cloud-based-5g-radio-solutions/
[442] CCS Insight: Open RAN: The long journey from supporting act to lead role. Available at https://www.interdigital.com/white_papers/open-ran-the-long-journey-from-supporting-act-to-lead-role

4.8.3 Other software platforms

In addition to offering a wide range of cloud-based solutions spanning network elements (core, RAN, spectrum), big tech providers also offer operation and business support systems (OSS/BSS).

A key advantage of cloud-based platforms is the ability to leverage data analytics and machine learning/artificial intelligence solutions to enable MNOs to achieve benefits in various ways such as quicker network deployment and buildout, improvements in operational efficiency, transformation of customer experience, and opening growth opportunities in enterprise verticals.

For MNOs seeking to execute new business strategies, common challenges include a lack of flexibility in their OSS/BSS platforms, high costs of managing legacy IT systems and operations, and maintaining regulatory compliance. Cloud-based OSS/BSS solutions can offer MNOs a wider range of capabilities, greater flexibility, and configurability in an increasingly complex digital marketplace. These solutions allow multi-tenancy (operated on a single platform in one location) and can support multiple business lines (mobile, fixed-line, broadband, finance, utilities, new verticals), charging models (subscription, usage-based, different payment methods for mobile bills) and localisation features (e.g., customised invoices, language, currencies).[443]

Within the telecoms industry, there is growing recognition of the need for such solutions, though the migration to cloud-native solutions can be hampered by various reasons including the lack of in-house IT expertise and financial constraints.[444] In this area, cloud-based technology providers are actively partnering with major OSS/BSS vendors such as Amdocs, Ericsson and Netcracker to work with telcos on their digital transformation process.[445]

Improving customer experience is another area where cloud-based operators have an increasingly important role. The use of real-time, data-driven insights, such as the impacts of networks, fraud incidents, customer service interactions and service pricing, allows MNOs to make more timely decisions and better anticipate users' needs, by customising market campaigns and offering more personalised products, thereby improving services and reducing churn.[446] For example, Google Cloud's BigQuery platform provides a scalable data analytics solution for telecommunications companies to store, process, and analyse data in real time, and build personalisation models on top of this data.[447]

Big tech's influence also extends to customer experience where MNOs have been introducing cloud-based AI applications to digitise their call centre operations to help lower costs and increase customer satisfaction.[448] One example is Telefonica's Aura virtual digital assistant platform[449] which runs on Microsoft's cloud and AI services. Aura, which is available on different connected devices and platforms, allows customers to manage their products and services with Telefonica (e.g., video-calling, TV channel control) and access real-time support through voice interaction. Through the same platform, Telefonica has also introduced the Movistar Living Apps[450] offering digital commerce with partners, including Air Europa, La Ligua, and Iberia, through Telefonica's ecosystem of home devices.

[443] AWS, Operations, simplified. Available at: https://apps.kaonadn.net/5146287135522816/index.html#section=operations
[444] Omdia, 20 May 2021, Migrating BSS to the Cloud: Cloud-Native BSS Application Development. Available at: https://www.oracle.com/a/ocom/docs/corporate/analystrelations/2021migrating-bss-to-the-cloud-cloud-native-bss-app-dev.pdf
[445] Amdocs, 10 November 2020, Amdocs Collaborates with AWS to Accelerate Telecommunications Industry's Move to the Cloud. Available at: https://www.amdocs.com/news-press/amdocs-collaborates-aws-accelerate-telecommunications-industrys-move-cloud
[446] AWS, 2021, Customer experience, reimagined. Available at: https://apps.kaonadn.net/5146287135522816/index.html#section=customer_exp
[447] Google, 2021, Press Releases. Available at: https://cloud.google.com/press-releases/2020/0305/google-cloud-telco-strategy
[448] Google Cloud, 2021, Contact Centre AI. Available at: https://cloud.google.com/solutions/contact-center/
[449] Microsoft, 11 June 2019, Spanish telco builds digital assistant based on natural language bot, engages customers on new level. Available at: https://customers.microsoft.com/en-us/story/726906-telefonica-media-telco-cognitive-services-azure
[450] Telefonica, 2021, Discover Living Apps, the new channel to reach your customers. Available at: https://aura.telefonica.com/living-apps

4.9 OTT services

There has been a sustained shift by consumers towards over-the-top (OTT) communications services as a replacement for traditional telecommunication services. As noted in a PPMi report for BEREC,[451] the "rise in the use of digital platforms and social networks coincides not only with increase demand for broadband internet, but also with a decrease in the use of SMS, MMS and mobile phone calls."

In particular, Facebook has a significant role in provision of alternate OTT communications services. Its products (such as WhatsApp, Facebook Messenger, Instagram and Facebook) are the most popular for both interpersonal communications and social media platforms.[452] WhatsApp in particular is the most used OTT communications app in the EU (62% of PPMi's survey respondents use it daily). Facebook Messenger ranks second, with European markets being either WhatsApp or Messenger-dominated. Although PPMi's study finds that consumers often use more than one messenger app, these are often used for distinct purposes by individual consumers (for example, to access different types of information or to communicate with different social groups such as family on one platform and friends on another).

Recent concerns around data privacy and security protection have caused some consumers to migrate to other applications. For example, many users migrated to privacy-first communication apps Signal and Telegram as part of a global backlash against WhatsApp's new privacy policy issued in January 2021.[453] Nevertheless, consumers tend to remain with their main messenger application; 76% of EU consumers surveyed had not switched their main messenger app over the prior 12 months.[454] This loyalty is driven by inertia, brand identification and attachment to using a certain application. Free-of-charge usage and having friends and family using a particular OTT app (network effects) were also reported as strong pull factors for adopting a new service.

Nonetheless, there remains a lot of competition and innovation in OTT communications despite the large market presence of Facebook as the current lead provider in OTT communications apps. Other technology firms have continued to develop their OTT offerings. Videoconferencing platform Zoom has emerged as a lead platform as a result of the pandemic, outstripping growth and in some cases displacing traditional business-focused OTT communication platforms such as MS Teams, Cisco WebEx and Google Hangouts.[455]

Innovation in OTT communications has been primarily driven by technology companies, and MNOs' lack of software capability has meant that it has been difficult for MNOs to credibly enter with their own products and capture part of the OTT communications market. The mobile industry's rich communications standard (RCS), that was supposedly a successor to SMS, is an example of MNOs failure to launch OTT services. Joyn, the GSMA-backed RCS standard, struggled to gain significant operator support. Only 7% of operators surveyed in 2019 thought that the solution could challenge OTT voice and messaging services such as Facebook, Skype and WhatsApp.[456] The Joyn project was discontinued though Google has adopted RCS messaging in recent years as a possible Android messaging solution as a rival to Apple's iMessage service.[457]

Big tech has made several high profile acquisitions in this sector, including Facebook's acquisition of WhatsApp, Viber by Rakuten and LinkedIn and Skype by Microsoft. The OTT communications market was estimated to grow

[451] PPMi, 10 June 2021, Analysing EU consumer perceptions and behaviour on digital platforms for communication, analysis report prepared for the Body of Regulators for Electronic Communications (BEREC), BoR (21) 89. https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/9965-analysing-eu-consumer-perceptions-and-behaviour-on-digital-platforms-for-communication-analysis-report

[452] PPMi for BEREC, 10 June 2021.

[453] The Guardian, 24 January 2021, Is it time to leave WhatsApp – and is Signal the answer? Available at: https://www.theguardian.com/technology/2021/jan/24/is-it-time-to-leave-whatsapp-and-is-signal-the-answer

[454] PPMi for BEREC, 10 June 2021.

[455] Vox, 4 December 2020, The pandemic was great for Zoom. What happens when there's a vaccine? Available at: https://www.vox.com/recode/21726260/zoom-microsoft-teams-video-conferencing-post-pandemic-coronavirus

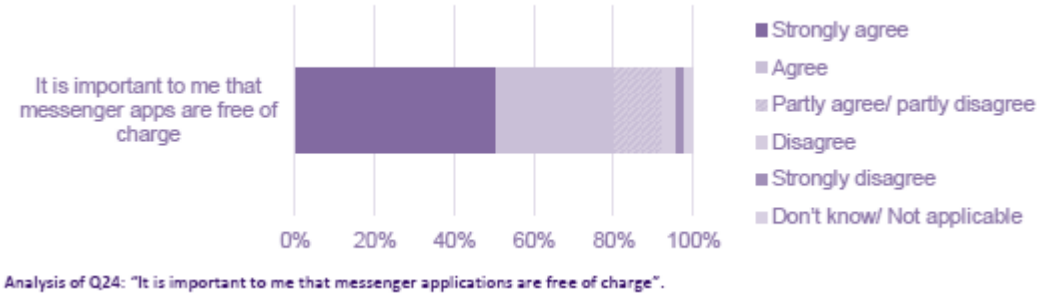
[456] Telecoms.com, 15 August 2013, Operators losing faith in Joyn. Available at: https://telecoms.com/171082/operators-losing-faith-in-joyn/

[457] Pocket-lint, 16 June 2021, What is RCS messaging? The new Android Chat texting service explained. Available at: https://www.pocket-lint.com/phones/news/144258-what-is-rcs-messaging-the-messaging-format-set-to-take-over-your-android-phone

by €32 billion between 2018 and 2021, though the estimate was made prior to the emergence of the COVID-19 pandemic and increased demand for OTT communications to support remote working.[458]

The results of PPMi's consumer survey highlight that free-of-charge access is the most important driver for consumers adopting OTT communication apps, as shown in Figure 4.3 below. Consumers ranked zero cost communications more highly than other factors such as additional personalisation or functionality such as video calling, group chats, file sharing, or ability to use GIF-images as a new mode of interpersonal communication. Younger cohorts of users ranked additional functionalities of higher importance when deciding whether to use traditional communications or OTT apps, and which OTT apps to select.

Figure 4.3: Importance of messenger applications being free of charge



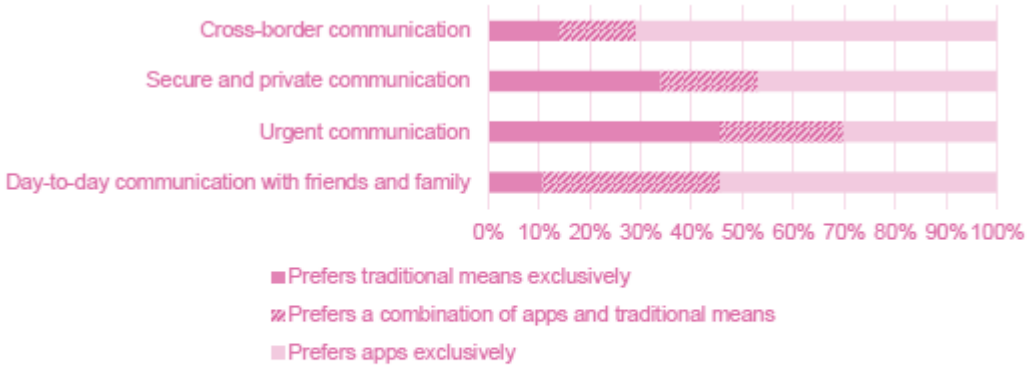
Source: PPMi for BEREC (June 2021)

Traditional and OTT communication services can be viewed as both complementary and as substitutes for each other. For example, previous research indicates that users tend to opt for voice calls to communicate with close friends and relatives, whereas other relationships tended to be maintained via WhatsApp or other social networks.[459] The tendency to use traditional or OTT communications tends to be driven by additional factors such as cross-border communications (due to cost differential) and urgency of communications (due to formality, preference for voice) as highlighted below.

[458] Total Telecom, 1 February 2018, Snapchat, WhatsApp, Skype… Players in a new OTT global communication market which will grow to €32 billion by 2021. Available at: https://www.totaltele.com/499158/Snapchat-WhatsApp-Skype-Players-in-a-new-OTT-global-communication-market-which-will-grow-to-32-billion-EUR-by-2021

[459] Fernández-Ardèvol and Rosales, 2018, Older people, smartphones and WhatsApp. Smartphone Cultures, 55-68. As summarised by PPMi for BEREC, 10 June 2021, page 91.

Figure 4.4: Preferred means of communication in different situations



Analysis of Q7: Which means of communication do you prefer to contact your friends or family members?; Q8: Which means of communication do you prefer when you need to contact someone urgently?; Q9: Which means of communication do you prefer when you wish your communication to be secure and encrypted?; and Q10: Which means of communication do you prefer to communicate with someone in another country? The response options for these questions included a list of messenger applications and number-based services. Each respondent could select up to two preferred means of communication for each situation.

Source: PPMi for BEREC (June 2021)

4.10 Regulatory responses to expanding big tech

There have been multiple responses to regulatory problems around the big tech including:

- Prohibited content, hate speech, and other consumer / user harms of various sorts.
- Competition concerns around search engines and other features.
- Sovereignty of data, storage and computing.
- Concerns with data privacy and processing.

In recent years there has been action from the UK, European Commission and others on a number of fronts, including in Europe the General Data Protection Regulation (GDPR), and the Digital Markets Act[460] and the Digital Services Act.[461] Other action from the European Union includes the European Alliance for Industrial Data, Edge and Cloud.[462] There is also action proposed on the home turf of much of the big tech industry with recent announcements from the Federal Trade Commission (FTC) chair, Lina Khan.

In the UK the government has recently announced a plan for digital regulation[463] aimed at driving growth and unlocking innovation. Key aspects of the announcement are:

- Promoting competition and innovation.

[460] Europarl, Proposal for a regulation of the European parliament and of the council on contestable and fair markets in the digital sector (Digital markets act) 2020-12. Available at: https://www.europarl.europa.eu/legislative-train/theme-a-europe-fit-for-the-digital-age/file-digital-markets-act
[461] Europarl, Proposal for a regulation of the European parliament and of the council of a single market for digital services (Digital services act) and amending directive 2000/31/EC. Available at: https://www.europarl.europa.eu/legislative-train/theme-a-europe-fit-for-the-digital-age/file-digital-services-act
[462] European Commission, 2021, European Alliance for Industrial Data, Edge and Cloud. Available at: https://digital-strategy.ec.europa.eu/en/policies/cloud-alliance
[463] UK Government, 6 July 2021, Digital Regulation: Driving growth and unlocking innovation. Available at: https://www.gov.uk/government/publications/digital-regulation-driving-growth-and-unlocking-innovation

- Keeping the UK safe and secure online.
- Promoting a flourishing democratic society.

The government is seeking to identify unnecessary regulations where possible and move to an outcome focused regulatory environment. It is also looking to identify underlying drivers of harm and to work through a collaborative approach with businesses and regulators. Measures to achieve international interoperability are to be considered.

While references to tech giants are not as explicit as in proposed EU legislation, there is a concern in the government about the market power of a few key technology companies and that this might be reducing opportunities for rivals, leading to lower innovation and less consumer choice.

The Online Safety Bill is aimed at creating a new regulatory regime to address illegal and harmful content online, with the aim of preventing harm to individuals in the United Kingdom. It:

- Imposes duties of care in relation to illegal content and content that is harmful to children.
- Imposes duties on providers in relation to the protection of users' rights to freedom of expression and privacy.
- Confers powers on Ofcom to oversee and enforce the new regulatory regime.

4.10.1 European Alliance for Industrial Data, Edge and Cloud

The Alliance aims to strengthen the position of EU industry on cloud and edge technologies and capacities. The Alliance is a key part of the EU's digital decade targets for 2030. Key objectives of the Alliance include:

- The development and deployment of data, computing and industrial ecosystems that support the digital transformation of the European industry and public sector and that are fully compliant with the EU legislative framework and the highest EU standards on data processing.
- The development and deployment of a European offering of next-generation competitive cloud and edge infrastructures and services, including completely interoperable, open, multi-vendor cloud platforms and services.

Gaia-X is an example of work around the initiative and is a direct response to the growth of non-EU hyperscalers. Principles for Gaia-X include:

- Implementation of secure federated identity and trust mechanisms (security and privacy by design).
- Sovereign data services which ensure the identity of source and receiver of data, and which ensure the access and usage rights towards the data.
- Integration of existing standards to ensure interoperability and portability across infrastructure, applications and data.
- Establishment of a compliance framework and Certification and Accreditation services.

Gaia-X members include entities like Microsoft in Austria, Google in Ireland, Oracle, Palantir, and Palo Alto. Hence, while it is a project initiated by Europe for Europe it does have non-European members and hyperscale players participate in its working groups.[464]

4.10.2 GDPR

The GDPR set out to enhance the control and rights of a natural person over their personal data. The EU promotes it as one of the toughest privacy laws in the world. The regulation came into effect on 25th May 2018 and there are potentially large fines (up to 4% of global turnover which amounts to €20 million) for failing to comply with GDPR rules. GDPR sets out a set of data protection principles including purpose limitation, storage limitation, accuracy and accountability and defines clear roles for the processing of data (e.g., data subject, data processor and data controller). The GDPR is implemented in the UK and falls within the remit of the Information Commissioners Office (ICO) to administer.

4.10.3 Digital Markets Act

The Digital Markets Act aims to ensure that digital platforms behave in a fair way online. It sets out to identify platforms with the ability to act as gatekeepers and to set standards for their behaviour to help deliver a fairer business environment while providing legal certainty for platforms. Examples of rules that might be applied to gatekeepers include:

- Prohibitions to discriminate in favour of own services.
- Obligations to ensure platform interoperability.
- Obligations to share, in compliance with privacy rules, data that is provided or generated through business users' and their customers' interactions on the gatekeepers' platform.

The Digital Markets Act is currently in the EU legislative process.

4.10.4 Digital Services Act

The Digital Services Act is intended to deal with a wide range of harms and behaviours around illegal goods, content or services. It is a complex legislative proposal covering a wide range of activity. Examples of proposed provisions include:

- Measures to counter illegal goods, services or content online.
- New obligations on traceability of business users in online marketplaces.
- Increased range of safeguards for users.
- Transparency measures for online platforms, including on recommendation algorithms.
- Obligations for very large platforms that reach more than 10% of the EU's population to prevent abuse of their systems by:

[464] AWS and the Gaia-X initiative. https://aws.amazon.com/blogs/publicsector/what-next-europes-data-revolution-aws-joins-gaia-x-initiative/

  - Taking risk-based action.
  - Independent audits of risk management systems.
- Codes of conduct and technical standards.

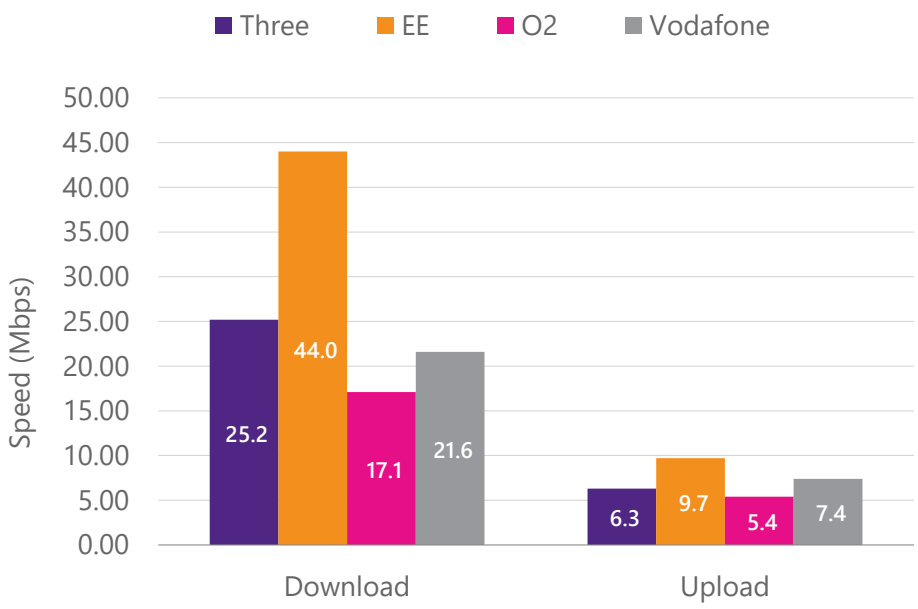
The rules will apply to all online intermediaries offering services in the single market, whether they are established in the EU or outside.

The Digital Services Act is currently in the EU legislative process.

Appendix A UK MNOs' performance

Figure A.1 shows average download and upload speeds for UK operators as reported by Opensignal in Q2 2021.[465] Users of EE's network experience the highest download and upload speeds, while network performance by other operators is substantially lower. O2 users experience the lowest download and upload speeds. UK operators perform worse than the operators from the HQN markets. Though the overall range of network speeds experienced in UK and Taiwan is similar, the larger Taiwanese operators provide substantially faster services than UK operators. A similar range of performance is observed in Japan, where the main three operators offer download speeds exceeding 40 Mbps, substantially outperforming UK operators.

Figure A.1: Network performance – download and upload speed (2021)

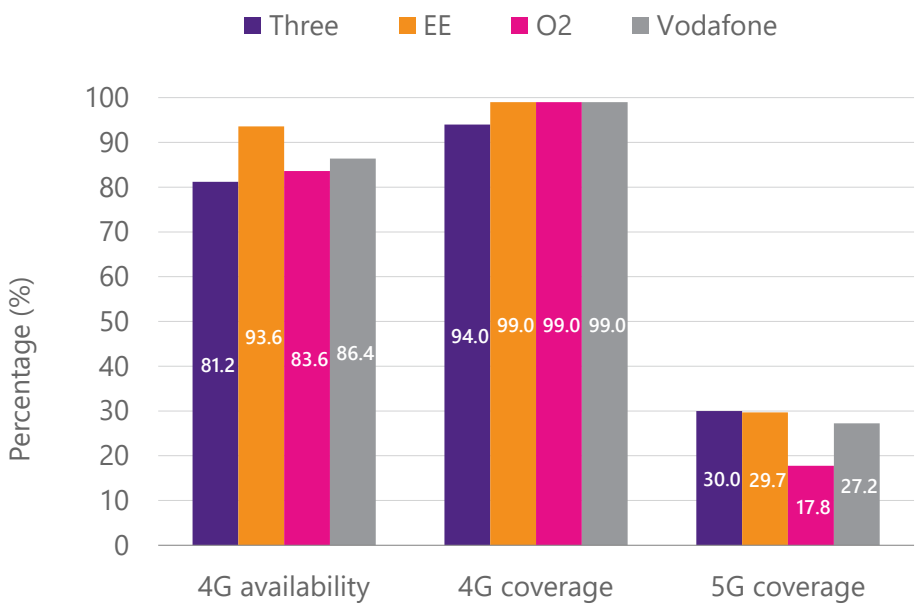


Source: Opensignal (September 2021)

Figure A.2 compares UK operators network availability in terms of network population coverage of 4G and 5G networks reported by GSMA Intelligence and Opensignal's 4G network availability measure (the percentage of time that users can connect to the 4G network).

[465] Opensignal, September 2021, United Kingdom Mobile Network Experience Report. Available at: https://www.Opensignal.com/reports/2021/09/uk/mobile-network-experience

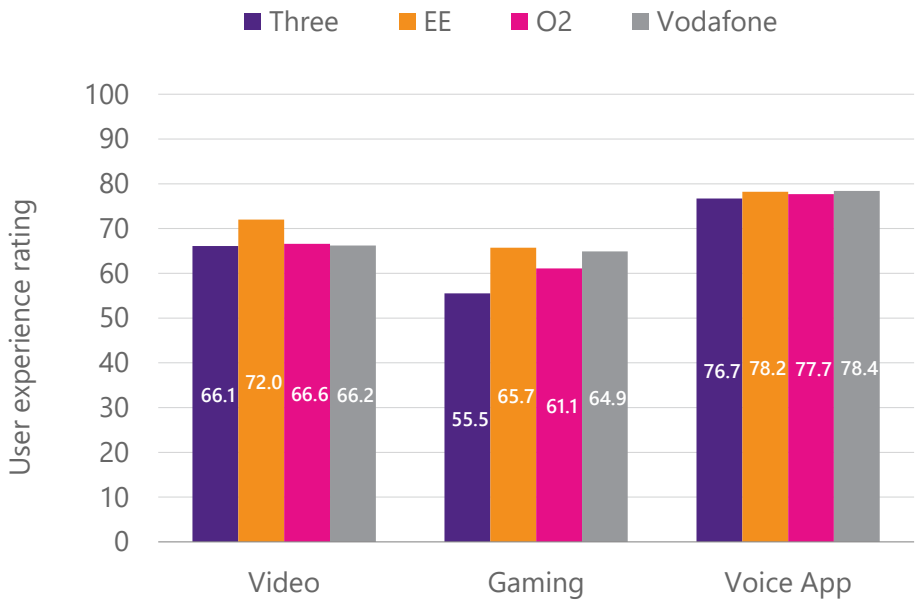
Figure A.2: Network performance – 4G availability (% time accessible) and 4G/5G coverage (% population)



Source: Opensignal (April 2021; 4G availability), GSMA Intelligence (June 2021; 4G population coverage, 5G population coverage)

Figure A.3 reports the Opensignal's user experience scores for video, gaming and voice apps by UK operator. User rating for voice app experience is very similar across all networks and the largest divergence in operator performance is in gaming experience. EE is the highest performing operator across these metrics and Three is the lowest.

Figure A.3: User experience score, of 100 (2021)



Source: Opensignal (April 2021)

Appendix B Opensignal user experience metrics

The tables below provide Opensignal's scoring criteria for user experience for video, gaming and voice applications.

Figure B.1: Opensignal scoring criteria for video experience

Score	Video experience
75 or above	Excellent. Very consistent experience across all users, video streaming providers and resolutions tested, with fast loading times and almost non-existent stalling.
65 < 75	Very Good. Generally fast loading times and only occasional stalling but the experience might be somewhat inconsistent across users and/or video providers/resolutions.
55 < 65	Good. Less consistent experience, even from the same video streaming provider and particularly for higher resolutions, with noticeably slower loading times and stalling not being uncommon.
40 < 55	Fair. Not a good experience either for higher resolution videos (very slow loading times and prolonged stalling) or for some video streaming providers. Experience on lower resolution videos from some providers might be sufficient though.
Under 40	Poor. Not a good experience even for lower resolution videos across all providers. Very slow loading times and frequent stalling is common.

Figure B.2: Opensignal scoring criteria for gaming experience

Score	Gaming experience
85 or above	Excellent. The vast majority of users deemed this network experience acceptable. Nearly all respondents felt like they had control over the game and they received immediate feedback on their actions. There was not a noticeable delay in almost all cases.
75 < 85	Good. Most users deemed the experience acceptable. Gameplay experience is generally controllable and the user receives immediate feedback between their actions and the outcomes in the game. Most users did not experience a delay between their actions and the game
65 < 75	Fair. Users found the experience 'average'. In most cases the game is responsive to the actions of the player with most users reporting that they felt like they had control over the game. The majority of players reported that they noticed a delay between their actions and the outcomes in the game.
40 < 65	Poor. Most users found this level of experience unacceptable. The majority of users reported seeing a delay in the gameplay experience and they did not receive immediate feedback on their actions. Many users felt a lack of controllability in the Games Experience.
Under 40	Very Poor. Nearly all users found this level of experience unacceptable. Almost all users experienced a noticeable delay within the game, with most of them not feeling like they had control of the gameplay. The vast majority of players didn't receive immediate feedback on their actions.

Figure B.3: Opensignal scoring criteria for voice app experience

Score	Voice app experience
95 or above	Excellent. Most users are very satisfied. Operator provides consistently good OTT voice quality experience across the customer base.
87 < 95	Very Good. Most users are satisfied. Operator generally provides good OTT voice quality experience. Occasionally, there may be some impairments to the call, primarily related to level of loudness.
80 < 87	Good. Many users are satisfied. Minor quality impairments experienced by some users. Sometimes the background is not quite clear, it can be either hazy or not loud enough. Clicking sounds or distortion is very occasionally present.
74 < 80	Acceptable. Users are satisfied. Perceptible call quality impairments experienced by some users. Short duration of clicking sounds or distortion can be heard, and/or the volume may not be sufficiently loud. Listener is generally able to comprehend without repetition.
66 < 74	Poor. Many users dissatisfied. Call quality impairments experienced by many users. Distortion, clicking sounds or silence experienced during the call, which is perceptible and can be annoying.
60 < 66	Very Poor. Most users dissatisfied. Significant call quality impairments experienced by most users. Occasional instances of distortion, clicking sounds or silence experienced during the call. It can be difficult to understand parts of the conversation without repetition.
45 < 60	Unintelligible. Nearly all users are dissatisfied. Frequent instances of long pauses, clicking sounds or distortion can be heard during the call. Frequent repetition is required to be comprehensible, or there are frequent conversation overlaps.
Under 40	Impossible to communicate