European Commission

Technological developments and roaming

FINAL REPORT

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Digital Single Market

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Abstract

This study assesses technological and other market developments which could impact competition in wholesale and/or retail roaming markets over the medium term (5-10 years), with a view to understanding whether regulation of data, voice and SMS roaming will continue to be necessary going forwards.

Our analysis suggests that there does not seem to be a case for significant changes to the (retail or wholesale)rules applying to international roaming by individual travellers under the current review (without prejudice to review of maximum wholesale rates). However, the deployment of eSIM and evolution in over-the-top voice and messaging services should be monitored with a view to assessing their impact on competition in retail roaming markets in the medium term. Developments in 5G and IP-based mobile communications in the coming years could also affect the nature, variety and pricing of wholesale roaming products going forwards.

In the more immediate term, it may be helpful to review whether there is a need for more explicit rules or guidelines governing access requests for permanent roaming for the purposes of connectivity for M2M/IoT.

Kurzfassung

In dieser Studie werden technologische und andere Marktentwicklungen bewertet, die sich mittelfristig (5-10 Jahre) auf den Roaming-Märkten für Groß- und/oder Endkunden auswirken könnten. Dabei wird untersucht, ob diese Entwicklungen des Daten-, Sprach- und SMS-Roaming Regulierungseingriffe auch in Zukunft notwendig machen werden.

Nach unserer Analyse scheint es keinen Grund für eine wesentliche Änderung der (Endkunden- oder Wholesale-)Vorschriften für das Roaming von Einzelreisenden im Ausland innerhalb der aktuellen Überprüfung (Review) der Regulierung zu geben (unbeschadet der Überprüfung der maximalen Wholesale-Preise). Die Einführung von eSIM und die Entwicklung der Over-the-Top Sprach- und Messaging-Dienste sollten jedoch beobachtet werden, um ihre Auswirkungen auf den Wettbewerb in den Roaming-Märkten für Privatkunden mittelfristig zu bewerten. Die Entwicklungen der kommenden Jahre in der 5G- und IP-basierten Mobilkommunikation könnten sich auf die Art, Vielfalt und Preisgestaltung der zukünftigen Roaming-Produkte im Großhandel auswirken.

Kurzfristig kann es hilfreich sein zu prüfen, ob explizitere Regeln oder Richtlinien für Zugangsanträge für permanentes Roaming zum Zwecke der Konnektivität für M2M/IoT notwendig sind.

0 Executive summary

This study aims to support the Commission in assessing technological and other market developments which could impact competition in wholesale and/or retail roaming markets over the medium term (5-10 years), with a view to understanding whether regulation of data, voice and SMS roaming will continue to be necessary going forwards. A summary of key findings follows.

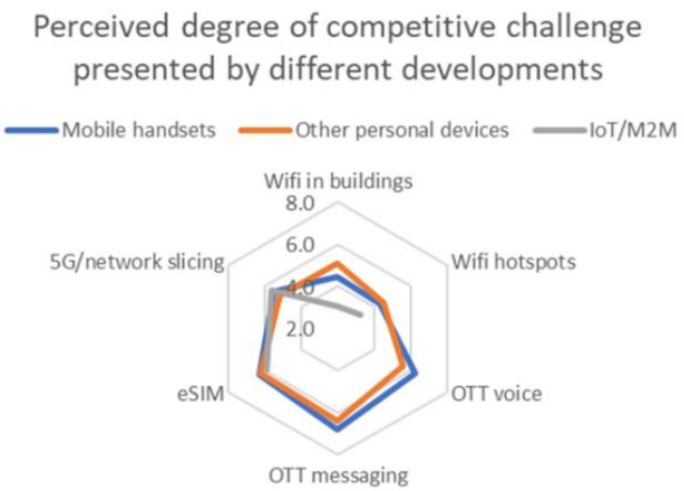
0.1 Key technological and market developments

Developments that are likely to be relevant to competition in roaming in the medium term, include developments which enable end-users to *bypass* roaming such as Wi-Fi and OTT services, developments which *facilitate entry* into the roaming segment such as eSIM, and new generation technologies such as 5G, VoLTE and RCS, which affect the nature of roaming products and *require renegotiation* of existing agreements.

Our analysis suggests that there may be different competitive dynamics in markets for mobile handsets and personal devices, compared with the more nascent market for M2M/IoT.

Responses to an online survey conducted for this study, suggest that market participants consider that OTT voice and messaging services are likely to present the greatest competitive threat to traditional roaming offers for mobile voice and SMS, while eSIM and (especially for IoT) 5G and network slicing – are also expected to disrupt roaming markets.

Perceived degree of competitive challenge presented by technological, market and service developments (1=limited challenge, 10=significant challenge)



Source: WIK-Consult based on stakeholder survey, n=31.

The following table provides a summary of the degree to which we expect different developments might impact competition in roaming markets in the medium term, distinguishing their potential impacts on data, voice and SMS markets, and for personal devices compared with IoT/M2M.

Summary of conclusions concerning the implications of technological and market developments on competition in roaming markets in the medium term

Personal devices	Data roaming		Voice roaming		SMS roaming		Dependencies
	Retail	Wholesale	Retail	Wholesale	Retail	Wholesale	
Wi-Fi hotspots	+	+	(+) via OTT		(+) via OTT		
eSIM	+(+)		(+)		(+)		eSIM take-up, wholesale access or roaming
5G/network slicing		+/-					5G deployment and take-up
OTT voice and SMS			++	+	+++	++	Reliable low cost data connection
Capacity trading exchanges		(+)		(+)		(+)	Participation of multiple MNOs per country

+ indicates increase in competition, (+) minor or uncertain increase, - indicates potential competitive challenge

IoT	Data roaming	
	Retail	Wholesale
Wi-Fi hotspots	(+)	(+)
eSIM	+++	
5G/network slicing		++/-

Source: WIK-Consult.

Wi-Fi hotspots are expanding across Europe and are likely to remain attractive for reasons of cost, quality and convenience. Wi-Fi technologies are evolving to provide increased download speeds, and companies have emerged which seek to aggregate hotspots from different users or "homespots" to facilitate ease of use for travellers. However, Wi-Fi is unlikely to present a comprehensive substitute for mobile data "roaming" for consumers or mobile IoT because it lacks complete coverage. Moreover, mobile capabilities are evolving alongside Wi-Fi, closing the capability gap, and mobile operators may increasingly use the capabilities to seamlessly integrate Wi-Fi technologies within their mobile offer in a 5G environment, thereby encompassing some of the advantages of this technology that currently encourage users to seek out Wi-Fi as an alternative.

OTT is already replacing mobile calls and SMS for certain purposes, domestically as well as when roaming, and for business applications as well as consumer. Conversely, more attractive roaming offers (based on RLAH) may have tempted end-users to switch to mobile voice rather than bypassing the network. There is likely to be residual demand for mobile communications from users without smartphones and for calls requiring any-to-any connectivity. However, OTT could limit the potential for mobile operators to increase voice and messaging prices, if cost-effective data roaming or alternatives are available.

eSIM is an important development that could facilitate competition and switching in mobile connectivity including roaming. Its effects on competition may differ for different market segments, and depend on the way the standard is implemented and influenced by different interest groups including mobile network operators and device manufacturers. The most significant prospects that eSIM could bring for new entry could be in connectivity for IoT including connected cars (where its use is already established) as well as in the supply of global connectivity to previously connected (but not mobile connected) devices such as tablets and laptops. MVNO/As, verticals and device manufacturers are likely to play an increasing role in providing connectivity in this space. eSIM could also enable customers to select separate specialist roaming providers on their mobile handset, or facilitate their use of local mobile providers (local break-out). However, customer take-up of specialist services might be limited, while local break-out presents other challenges, including trust (for the end-user), identification and security. It is possible that the threat of such competition could limit the ability of MNOs to raise prices, but eSIM in consumer devices is in its infancy and the impact has yet to be seen. The effects of eSIM on competition in consumer roaming in the long term could be significantly improved if GSMA standards were to be revised so as to remove the current limitation of one profile per eSIM.

5G technologies are likely to change the nature of roaming services e.g. by enabling quality and prioritisation as additional parameters as well as potentially affecting the commercial model applied, e.g. basing pricing on bandwidth as opposed to usage. Network slices could also provide options for MNOs and MVNOs to use access agreements as an alternative to traditional roaming as well as enhancing their ability to have more flexibility on service differentiation (latency, security etc), which could prove to be very important for certain vertical use cases. However, as 5G roaming, wholesaling models and vertical use cases have not yet been defined, the impact of 5G on competition in roaming/global connectivity markets is not yet clear. 5G could provide increased potential for new entry and retail competition if MNOs see its capabilities as an opportunity to build a diverse wholesaling model. Equally, if this is not the case, fears have been expressed, that 5G could potentially present a threat to multi-national MVNOs which would need to renegotiate existing arrangements, which are often tied to specific technology generations.

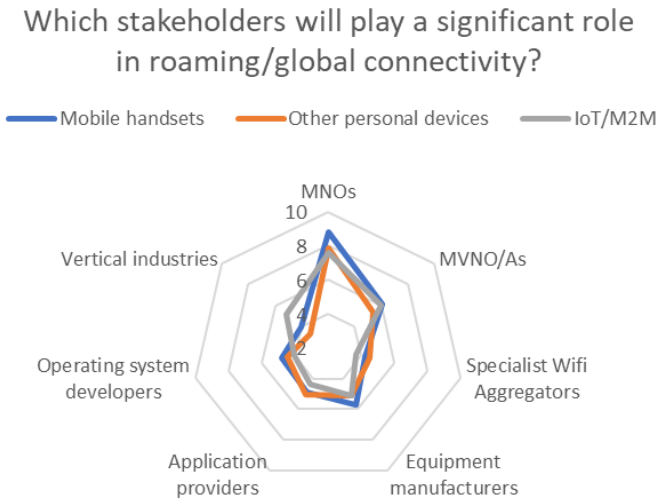
RCS is a standard for rich IP-based communications that is intended to replace existing mobile calling and SMS technologies. It is likely to narrow the gap between the functionality of mobile communications compared with OTT and provide RCS-based communications services which are interoperable between mobile network operators. RCS and VoLTE could change the nature of the services provided and the billing metric. These developments seem unlikely to change the competitive dynamics in mobile roaming markets, but may require new agreements or the renegotiation of existing agreements which could pose challenges to existing or new MNOs or MVNO/As which lack bargaining power with respect to larger MNO groups.

At the same time, new models for **wholesale capacity trading** for roaming are being explored. Proponents of such models claim that these platforms could boost competition in roaming wholesale markets, by anonymising trading (which is currently conducted through face-to-face bilateral negotiations) and by breaking the link between outbound and inbound traffic, which penalises operators and MVNOs which have little to offer in exchange for roaming access. Digitised trading may also be needed to handle the increased diversity of data roaming requirements that may arise with 5G. However, a key challenge with such models is that they rely on participation by multiple operators in each country, and there is a lack of incentive for larger mobile groups to participate.

0.2 Main actors in cross-border connectivity

Traditional mobile network operators are considered likely to continue to play the most significant role in the provision of international roaming connectivity in the medium term. However, new IoT/M2M services and business models alongside entry enablers such as eSIM are expected to increase the scope for new players or types of players to gain a foothold in markets for cross-border data connectivity. The main beneficiaries seem likely to be mobile virtual network operators and aggregators. Device manufacturers and verticals are also likely to play an increasingly important role as they look to bundle connectivity or provide interfaces or options for connectivity into their offers to consumers.

Which stakeholders will play a significant role in roaming/global connectivity? (1=limited role, 10=significant role)



Source: WIK-Consult based on stakeholder survey, n=33.

0.3 Implications for regulation

There does not seem to be a case for significant changes to the regulatory rules applying to international roaming under the current review (without prejudice to review of maximum wholesale rates). There are nonetheless a number of issues which our analysis suggests could benefit from more immediate attention.

One issue that was raised by MVNO/As interviewed for this study is that differing rules in different countries or different approaches by operators to permanent roaming could affect the potential to deploy IoT services across the single market.[1]

It could thus be helpful to review whether there is a need for more explicit rules or guidelines governing access requests for permanent roaming for the purposes of connectivity for M2M/IoT. In order to avoid unintended use of permanent roaming for personal communications[2] as well as addressing concerns of IoT connectivity providers,[3] it might also be helpful to provide guidance on how M2M should be

1 One case that was highlighted to illustrate challenges in obtaining roaming in the context of IoT was the dispute between Transatel and Telefonica Deutschland that was referred to the German regulator BNetzA. https://www.transatel.com/in-the-press/transatel-wins-german-regulatory-decision-on-access-to-telefonica-data-roaming/.

2 The potential use of eSIM to enable multiple contracts for mobile "roaming" connectivity with different identifiers could in theory make it harder to identify users which are in practice permanently roaming.

3 Interviewees noted that there could be a lack of clarity about whether a roaming application was "M2M" or involved personal interaction, especially in cases – such as connected cars – where different applications may be provided by the same global connectivity provider under the same contract for different purposes in parallel (e.g. telemetry and in-car entertainment).

distinguished from personal communications, and assess what action could reasonably and proportionately be taken by MNOs to enforce conditions they may apply for the use of permanent roaming.[4]

Finally, our research highlights the important role that standards can play in fostering innovation and competition in global connectivity markets. There could thus be a role for the EU to observe and if necessary support the development of standards that could allow QoS-guaranteed roaming for M2M applications requiring it, as well as closely following the implementation of standards adopted for eSIM to ensure that they evolve in such a way as to facilitate selecting and switching between multiple profiles.

Looking into subsequent reviews, although there is likely to be continued reliance on managed communications services for some customers and for some types of communication,[5] it is possible that OTT might provide a sufficient constraint on pricing to enable the withdrawal of retail roaming obligations (RLAH) on voice and SMS offers in the medium term.

However, due to the reliance of OTT on data connections, continued retail RLAH obligations for roaming data may be needed, unless there is evidence that competition from alternative roaming provision via eSIM (or the strong development – contrary to expectations - of local break-out) can effectively constrain retail data roaming prices. Such evidence might take the form of significant take-up of alternative roaming services or LBO by EU customers for travel outside the EU, leading to significant reductions in data roaming offers for such customers. It will not in any event be possible to gauge the effectiveness of alternative roaming offers until there is higher take-up of eSIM enabled smartphones.

At the wholesale level, it seems likely that data roaming regulation will continue to be required in the medium term to support both roaming for personal communications and provide a back-stop to support roaming for the growing IoT/M2M communications market. It is also possible that bottlenecks might emerge in the future with regard to wholesale provision of roaming services that provide assured QoS e.g. for M2M services, which may require intervention.

If competition challenges persist in wholesale data roaming (in its basic form and/or with QoS guarantees), there is a further question as to which kind of obligation would be most appropriate to address them. Respondents to the online survey conducted for this study suggested that wholesale price obligations would be the most appropriate solution

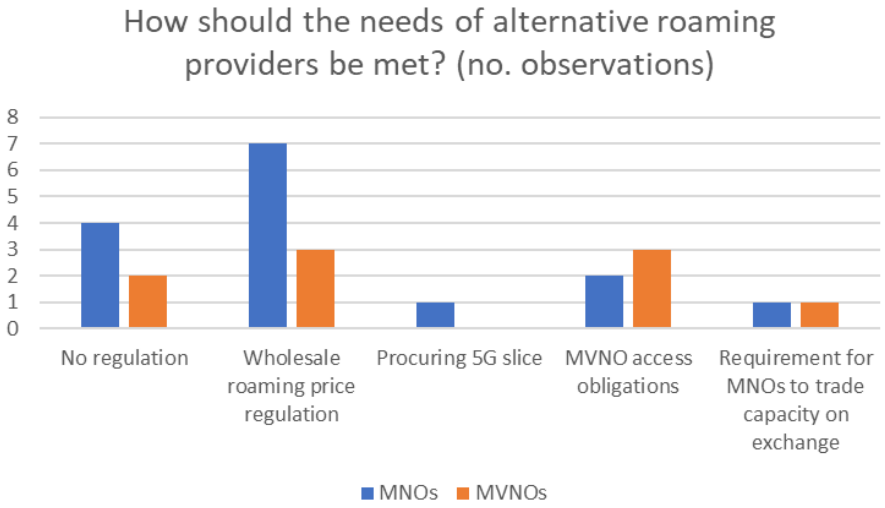
4 Any such guidance may however fall beyond the scope of the Roaming Regulation and may thus need to be addressed separately

5 For instance not all customers will subscribe to an OTT service, and not all customers will subscribe to *the same* OTT service. Especially for group calls, it is likely that number-based services (either using managed services or using alternatives such as SkypeOut that rely in part on managed services) will continue to be used for participants who are not subscribed to the same OTT service, or who lack smartphones or who (momentarily) lack access to mobile broadband.

– although MVNO providers also cited MVNO access obligations as of equal importance.

There were fewer calls for obligations to be applied on access to 5G network slices or requirements for MNOs to make access available via a capacity trading exchange. This may be because these options are less relevant, or could be due to the fact that they are less well developed, and therefore their significance less well understood. As there may be further insights into these developments in the coming years as 5G is deployed and commercial capacity trading platforms are launched, it may be helpful to analyse whether there is a need for any measures to be taken in these areas in a subsequent review of the roaming regulations.

How should the needs of alternative roaming providers be met – responses from MNOs and MVNOs



Source: WIK-Consult based on stakeholder survey, n=26.

It is less clear what intervention, if any, will be needed at the wholesale level concerning voice and SMS. If, on the basis of competition from OTT, retail markets are found to be prospectively competitive in the presence of data roaming regulation, this could warrant the deregulation of wholesale markets as well as the removal of RLAH (retail) obligations under a future review of the roaming regulations. However, it is possible that some challenges could persist for non-attached mobile operators and MVNO/As, including with the migration to IP-based services by means of VoLTE and/or RCS, and with the associated development of new wholesale offers. A future review of the roaming regulations might consider how to deal with this issue, in light of the experience in the negotiation of wholesale roaming agreements for IP-based voice and messaging.

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1 Introduction and study objectives

Problems in the functioning of international roaming markets have been apparent since international mobile roaming gained popularity two decades ago.

The earliest efforts to address these competition issues involved a DG Comp sectoral inquiry in 2000/2001[6], and the inclusion of a ”wholesale national market for international roaming on public mobile networks” in the 2003 Relevant Market Recommendation.[7] NRAs found these arrangements impractical because the NRAs controlled wholesale and retail prices only within their own Member State. They had no authority over the wholesale prices that their MNOs paid to MNOs in the Member States that their roamers visited, relative to their own residents. This meant that they could control the price of the service, but not the cost. Conversely, they had little motivation to control wholesale prices charged by their own MNOs, since doing so would benefit roamers from other Member States, but not their own residents.

As pan-European action was required to address the issues, the Commission successfully stepped in to introduce legislation. The earliest (2007) measures introduced a retail Eurotariff for calls and associated wholesale regulation. Later (2009 and 2012) measures strengthened and expanded the 2007 framework, and also attempted to promote competition in the roaming market by mandating the separate sale of regulated retail roaming services,[8] though these measures for separate sales had negligible effect.[9] Finally, with the Regulation of 2015/2120, the focus shifted to ending most surcharges for retail roaming through obligations for operators to provide ‘Roam like at Home’ service. In an attempt to ensure a sustainable provision of this policy, it was coupled with associated wholesale measures, a “fair use” policy and circumstances in which derogations were possible.

These measures have been both popular and effective in limiting previously excessive roaming charges throughout the EU. However, they still require significant ongoing regulatory intervention – notably on the wholesale level, while the roam like at home intervention on the retail level has the potential to impact alternative competitive solutions that might otherwise emerge.

With a view to limiting regulation to the extent necessary, the Roaming Regulation required the European Commission to review the degree of competition in national wholesale markets. It also required the Commission to report every two years on the

6 http://ec.europa.eu/competition/sectors/telecommunications/archive/inquiries/roaming/index.html
7 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32003H0311.
8 https://ec.europa.eu/digital-single-market/en/news/commission-implementing-regulation-no-12032012-separate-sale-regulated-retail-roaming-services.
9 J. Scott Marcus, Christin Gries, Christian Wernick, and Imme Philbeck (2016), Entwicklungen im internationalen Mobile Roaming unter besonderer Berücksichtigung struktureller Lösungen (Developments in international mobile roaming with special consideration of structural solutions), WIK study for the German BNetzA.

availability and quality of services, including those which are an alternative to regulated retail voice, SMS and data roaming, in light of technological developments.[10]

This study aims to support the Commission in assessing these developments.

- In Chapter 2 we identify the most relevant technological, service and market developments for further analysis.
- In Chapter 3, based on ex ante market analysis techniques, we assess the impact of relevant developments on competition in wholesale and retail roaming markets in the medium to long term, in the event that roaming regulation was removed (Modified Greenfield Approach).

10 Marcus, J. Scott, & Imme Philbeck. 2010. Study on the options for addressing competition problems in the EU roaming market - SMART 2010/0018, http://ec.europa.eu/information_society/activities/roaming/regulation/consult2011/index_en.htm.

2 Developments which might affect roaming

There are a number of current and foreseeable technological and service developments which have the potential to impact the roaming market in the medium to long term.

These developments can be broadly categorised into

(i) Developments which enable end-users to **bypass** data roaming or roaming calls and SMS by using alternative technologies to traditional mobile;

(ii) Technological developments and platforms which could facilitate **competition in mobile roaming and cross-border connectivity**; and

(iii) **New business models and players** entering the roaming space

These developments are linked. Specifically, the development of bypass technologies and technologies which facilitate competition in international roaming/mobile cross-border connectivity could facilitate the entry into the market and expansion of smaller mobile operators, multi-national MVNOs, and players which operate in linked fields such as equipment, applications or connected verticals.

In this chapter we discuss each of these developments in turn.

2.1 Technologies and services that enable roaming bypass

The first set of developments that may impact traditional roaming are services such as Wi-Fi, OTT voice and messaging, which in some circumstances enable mobile services to be bypassed (when roaming as well as domestically).

2.1.1 Wi-Fi and Wi-Fi Aggregation

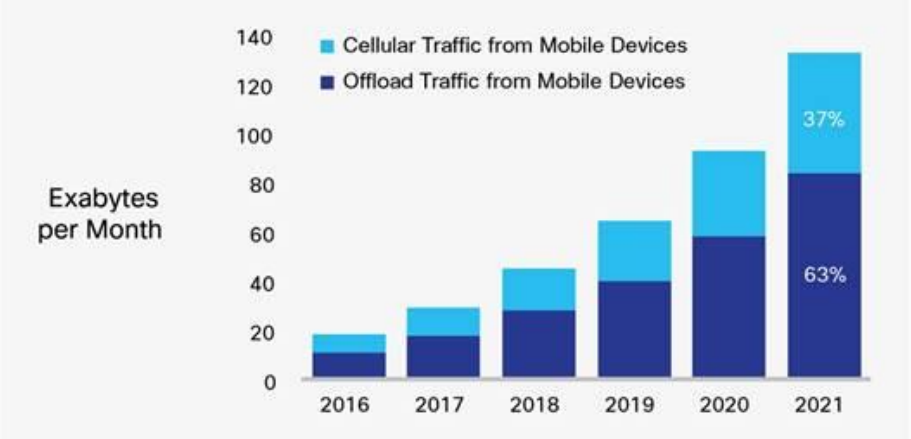
The increasingly widespread availability of Wi-Fi to the public is fundamental to the forms of substitution for traditional mobile roaming services that are probably most common in Europe today. In the case of roaming data, this substitution is direct. In the case of voice and SMS services, it is primarily by means of over-the-top (OTT) services.

Estimations of the proportion of mobile data traffic offloaded to Wi-Fi vary widely. While Cisco estimates that around two thirds of traffic will be offloaded to Wi-Fi by 2021,[11] a recent study suggested that surveyed users of connected devices such as smartphones downloaded nearly 8 times more data over Wi-Fi than over mobile data networks.[12]

11 Cisco VNI Mobile 2017 https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/mobile-white-paper-c11-520862.html.

12 Husnjak, Perakovic and Forenbacher (2018) Data Traffic Offload from Mobile to Wi-Fi networks: behavioural patterns of smartphone users.

Figure 2-1: Projected Wi-Fi offloading from mobile devices



Source: Cisco VNI.

When looking at the potential for Wi-Fi to act as a substitute or pricing constraint to mobile roaming, it is relevant to distinguish between Wi-Fi which is used in buildings such as homes, businesses and hotels, and Wi-Fi hotspots which are available outside or on moving vehicles.

While Wi-Fi in buildings is already very widely used today (and this situation seems unlikely to change significantly), public Wi-Fi hotspots across cities and regions, is a potential growth area, which could potentially offer an alternative in other situations where data roaming is currently used (outside hotels and airports). Public Wi-Fi hotspots/aggregation was therefore a key focus for this study.

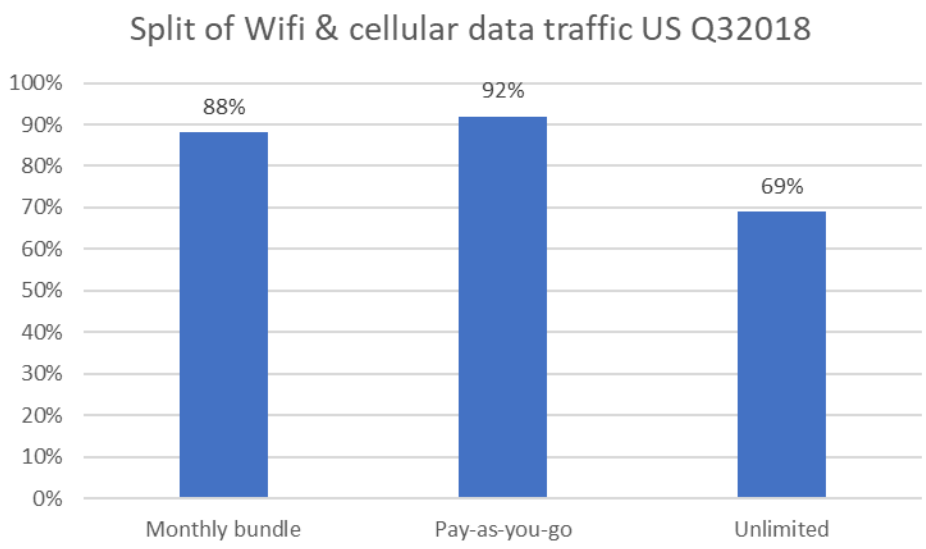
There is limited reliable data on the use of public Wi-Fi hotspots. However, online surveys suggest that it is relatively widely used – potentially by more than 70% of Internet users,[13] and that consumers use public Wi-Fi for a variety of purposes including sensitive tasks such as banking and checking email, despite the security risks.[14]

Wi-Fi benefits from a number of positive attributes which could encourage consumers to use Wi-Fi in preference to mobile data when available, including a perception that it is less expensive, simpler, faster and more reliable than mobile data access.[15] However, there is some evidence from the US (see Figure 2-2) to suggest that consumers might increase their usage of mobile data relative to Wi-Fi (i.e. substitute in the opposite

13 See for example this survey suggesting that 72% of respondents used public wifi, https://purple.ai/blogs/latest-survey-people-use-wifi-public-places/.
14 https://www.cnbc.com/2016/06/28/most-people-unaware-of-the-risks-of-using-public-wi-fi.html.
15 C. Hetting, “Seamless Wi-Fi offload: a business opportunity today,” 2013.

direction) if they have an “unlimited” data package. A 2018 study[16] suggests that users with sufficient data transfer allowance in their mobile plan, are less likely to belong to a higher data offloading category. Data captured by OpenSignal also suggests that US consumers spent less time on Wi-Fi as they moved to unlimited plans.[17] Conversely, users who pay for every SMS may be motivated to bypass not only while roaming but also domestically.

Figure 2-2: Split of Wi-Fi and cellular data traffic US Q3 2018



Source: Fierce wireless and strategy analytics.

To understand what the longer term impact might be of Wi-Fi e.g. in the context of hotels and other travel destinations as well as Wi-Fi aggregation services in the absence of retail roaming regulation, it is instructive to look at Wi-Fi solutions which have been developed for markets which are currently unregulated.

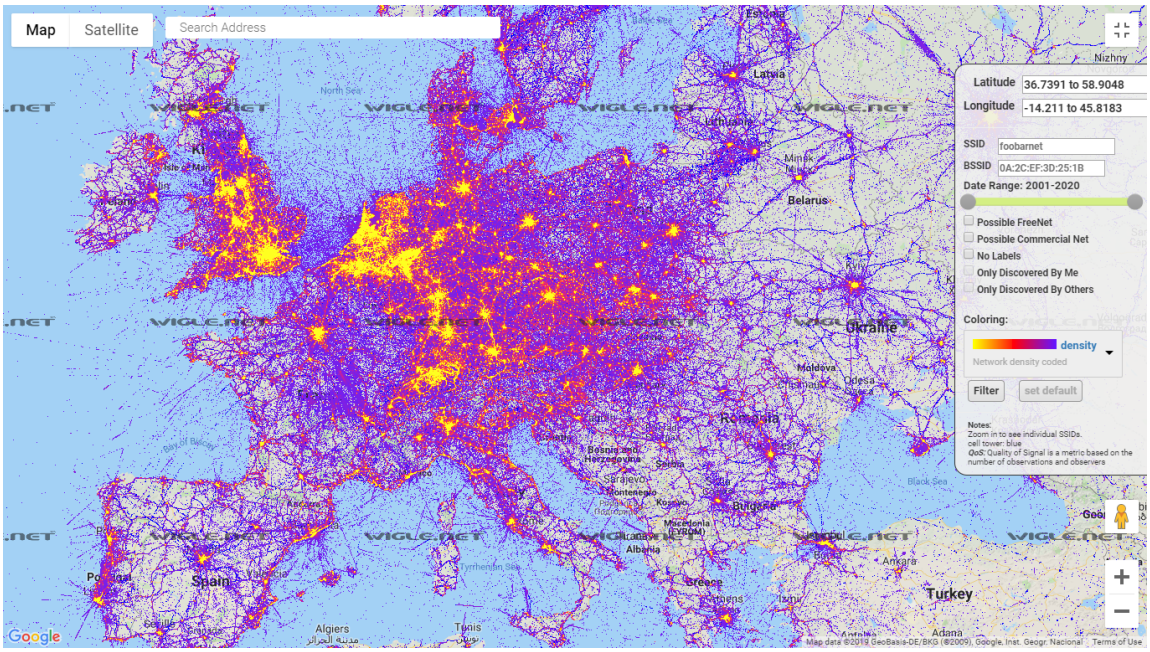
One example of a Wi-Fi aggregation solution is Google Fi, a solution, currently available only to US-based customers, which claims to allow customers to “roam for the same price as home” in 170+ countries and territories, including in Europe.[18]

At first sight, this looks like a business model that could become more relevant in Europe, in the event that existing roaming regulations were removed. However, there are a number of factors which mitigate against the potential for Wi-Fi alone to offer an alternative to mobile roaming over the medium to long term.

16 Husnjak, Perakovic and Forenbacher (2018) Data Traffic Offload from Mobile to Wi-Fi networks: behavioural patterns of smartphone users.
17 https://opensignal.com/blog/2018/04/19/time-spent-on-wifi-in-the-us-falls-as-users-move-to-unlimited-plans/.
18 https://fi.google.com/about/rates/.

Firstly and importantly, while Wi-Fi may offer good coverage in hotels and certain public areas including areas served with the aid of initiatives such as Wi-Fi4EU,[19] Wi-Fi does not offer contiguous and comprehensive coverage outdoors, and is unlikely to match the reach needed for travellers or for connected things such as cars, as can be seen from the coverage map below.

Figure 2-3: Wi-Fi coverage in Europe as displayed by Wigle.net Jan 2019



Source: WIGLE.net.

For this reason, even services such as Google Fi do not rely on Wi-Fi alone, but bundle WiFi and LTE offerings across multiple countries, allocating customers to the best available network.

The use of Wi-Fi as a complementary technology to boost network quality and reduce cost, has also been utilised by mobile operators, thereby reducing the case for customers to seek out a standalone or aggregator Wi-Fi solution when they travel.

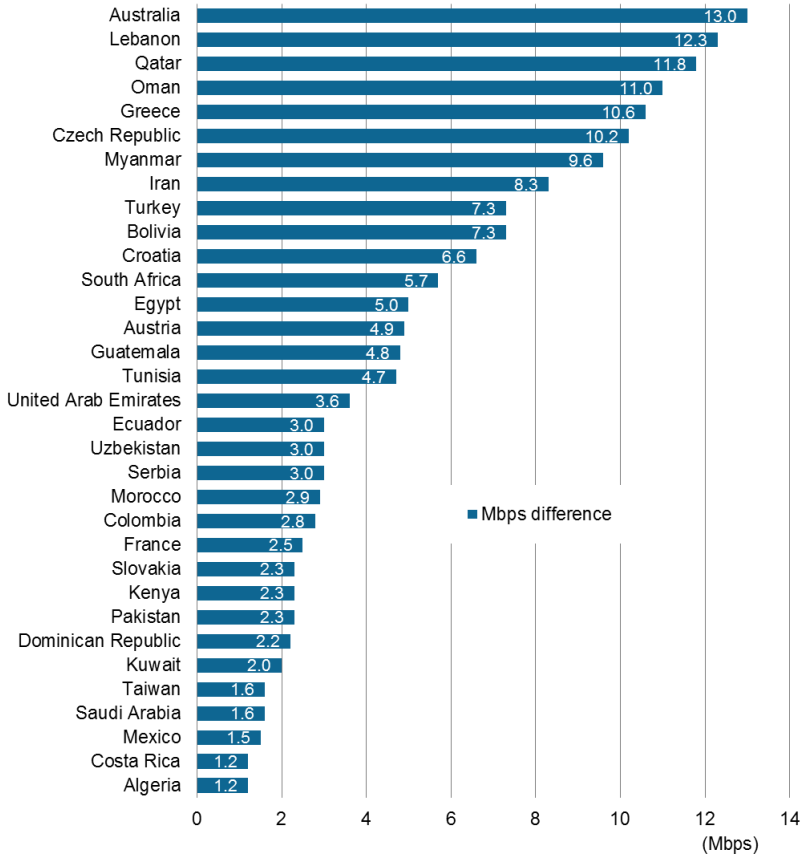
The capability for mobile network operators to practice seamless Wi-Fi offloading is already present in 4G networks. Japanese carrier KDDI announced in 2011 that it was installing more than 100,000 Wi-Fi hotspots,[20] and in 2015 claimed it had already achieved a target of 57% of Wi-Fi offloaded from their data network, with a target to increase this proportion, to limit LTE capex.[21]This trend may be supported by the

19 https://ec.europa.eu/digital-single-market/en/news/factsheet-wifi4eu.
20 https://www.cio.com/article/2406579/mobile/kddi-offloads-traffic-on-cellular-network-through-wi-fi.html.
21 http://broabandtrafficmanagement.blogspot.com/2015/05/kddi-wi-fi-offload-to-reach-65-lte.html.

advent of 5G technology, as one of the elements that can be expected in 5G networks is an ability to integrate unlicensed network technologies such as Wi-Fi for use with conventional licensed cellular networks.[22] Thus a 5G roaming customer might benefit from any superior quality characteristics available via Wi-Fi, without needing to consciously "bypass" the network (see Section 2.2.3).

The additional quality available via mobile 5G connections compared with LTE might also limit the relative attractiveness of Wi-Fi for travelling (and other) end-users. For example, an OpenSignal report found that while 10 years ago, Wi-Fi was faster, cheaper and had much greater capacity than mobile almost all of the time, this had changed by 2018,[23] such that the experience over LTE surpassed that of Wi-Fi in 41% of the countries analysed, including Greece, Austria and France (see Figure 2-4).It is possible that this effect might become more pronounced with the deployment of 5G.

Figure 2-4: Mobile download speed in excess of that offered via Wi-Fi



Source: OpenSignal (2018).

22 See for example Cisco 5G Vision series, https://www.cisco.com/c/dam/en/us/solutions/collateral/service-provider/ultra-services-platform/5g-vision-series.pdf.

23 See The State of Wi-Fi vs Mobile Network Experience as 5G arrives. OpenSignal November 2018, https://opensignal.com/reports-data/global/data-2018-11/state_of_wifi_vs_mobile_OpenSignal_201811.pdf.

That said, any potential replacement of Wi-Fi by mobile technologies will depend on the relative pricing of Wi-Fi compared with 5G[24] and the prevalence of data caps, which are likely to steer customers towards alternatives such as Wi-Fi. Perceived convenience may also play a role (see Section 2.2.3).

The relative attractiveness of Wi-Fi in comparison with 5G also depends on the evolution in the speed and quality of Wi-Fi connections – which has also evolved over time.[25] The status of fixed VHC deployment in different European countries is also relevant to the quality of Wi-Fi connections. Those countries with extensive FTTH infrastructure could be expected to benefit from higher capacity Wi-Fi connections (where available), while mobile technologies might outperform Wi-Fi in terms of speed in countries in which very high capacity fixed broadband is less well established. The degree of substitution of mobile roaming by Wi-Fi might therefore vary from one country or region to another.

Overall, this tends to reinforce the conclusion that, across the EU as a whole, it is unlikely that Wi-Fi can fully replace mobile data roaming/international connectivity. The high degree of pricing difference that has been maintained between public Wi-Fi and mobile data roaming domestically and while roaming (with an even greater differential in markets which are not subject to RLAH regulation) also suggests that at least on the demand side, it is unlikely that Wi-Fi can provide a sufficient pricing constraint to prevent potentially excessive charges for mobile data roaming.

2.1.2 OTT voice and messaging

It is possible that some aspects of roaming – especially voice and messaging – could become competitively supplied if OTT services provide viable alternatives. To date, about 86% of all Internet users in Europe use OTT communication services.[26]

VoIP OTT services such as Skype are increasingly being used not just by consumers, but by businesses as a replacement for traditional calls. According to our data, 26% of calls by consumers in 2017 within Germany were conducted using an OTT communications service. For international calls this share increases to 32%.[27]

24 Mobile broadband pricing beyond the included caps has tended to be significantly more expensive than Wi-Fi, even when charges levied by hotels or aggregators are taken into account.

25 A summary of the different Wi-Fi standards and speeds can be found at https://www.networkworld.com/article/3238664/wi-fi/80211-wi-fi-standards-and-speeds-explained.html.

26 GWI (2019). „Online Activities in the Last Month" - Used a chat or instant messaging service / app.

27 Referring to consumers. Source: Arnold, René, & Anna Schneider. 2018. Oops, I texted again. Bad Honnef, Cologne: WIK and Fresenius University of Applied Sciences.

According to the same study, close to one in ten OTT communications services offers PSTN connectivity today.[28]

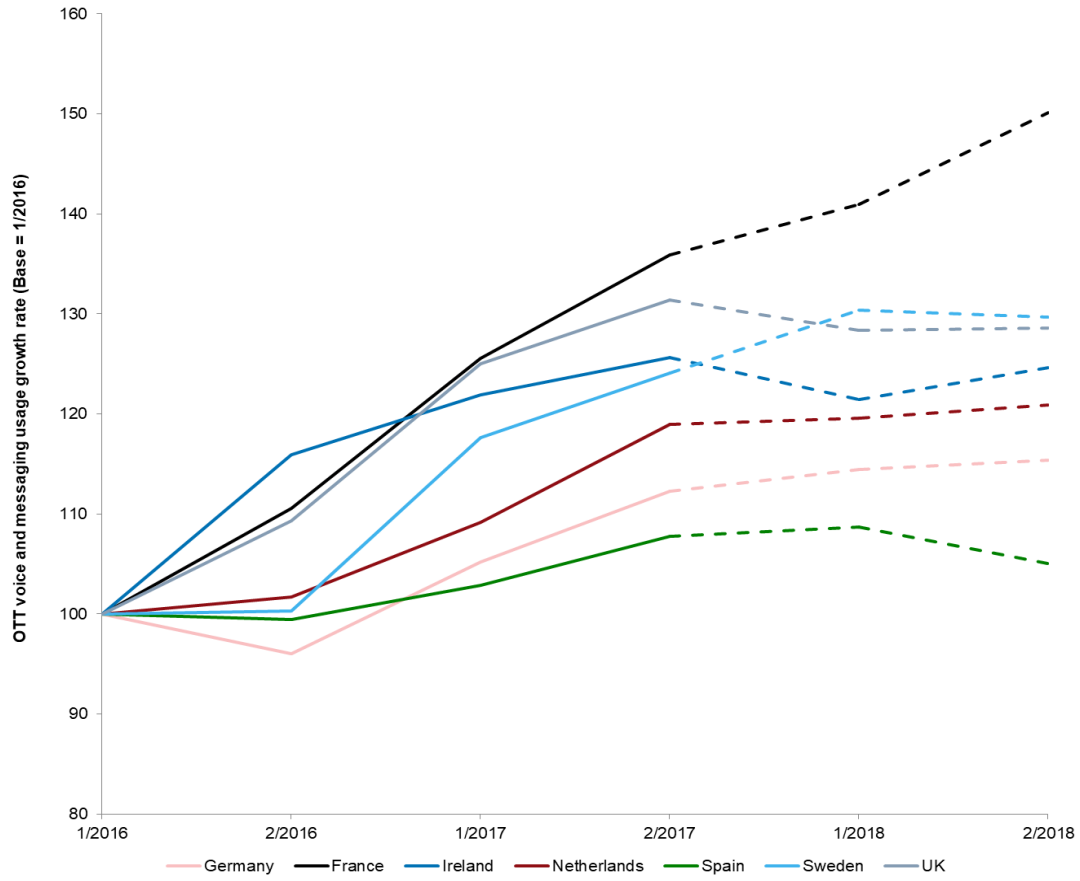
The replacement of SMS with online messaging, messaging applications or email is arguably at an even higher level. For example, in 2017 the share of messages sent via OTT service by German consumers rose to 73%.

An interesting illustration of the potential for substitution between OTT and managed calls (in the opposite direction) comes from analysis of the effects of RLAH regulation on customers' usage patterns for OTT compared with managed voice and messaging.

Data on the usage of the most popular OTT services for interpersonal communication across a sample of countries shows that a stagnation in the usage of these services started in or after the second half of 2017 (see figure below). This is in particular interesting since RLAH rules have been in force since June 2017. Even though the entire effect of this development cannot be attributed to the new regulation, it may arguably have had an impact on those who only used OTT services to communicate when abroad to reduce expenses. Figure 2-6 shows correspondingly that traffic of roaming calls and retail SMS rose significantly after the regulation was adopted.

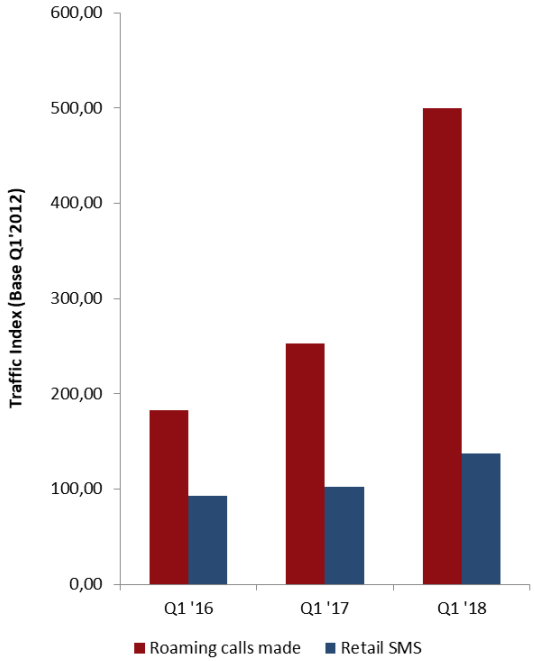
28 Again, this figure refers predominantly to consumer-focussed services. Business users often rely on unifed communications services, which technically are also VoIP systems offering PSTN connectivity where necessary.

Figure 2-5: OTT voice and messaging usage growth rate (Base = 1/2016), percentage of all internet users



Source: WIK estimates based on data provided by the GWI on usage of Facebook Messenger, Instagram, Snapchat and WhatsApp for interpersonal communication.

Figure 2-6: Traffic – EEA



Source: Own presentation of Data provided by BEREC: https://berec.europa.eu/eng/document_register/subject_matter/berec/reports/8251-international-roaming-berec-benchmark-data-report-october-2017-march-2018.

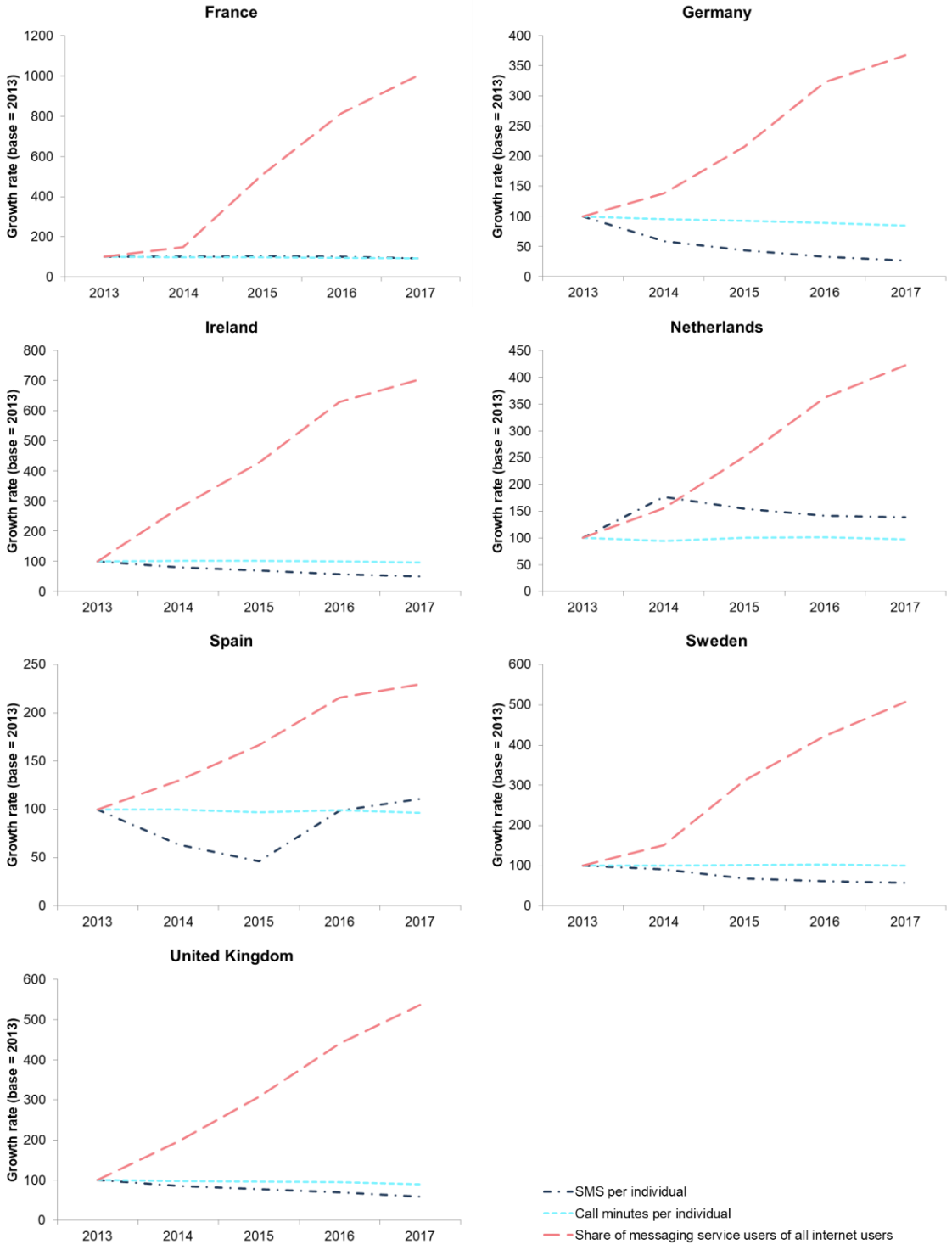
However, while replacement of certain calls with OTT and vice versa has undoubtedly occurred in response to price signals, there is evidence to suggest that OTT is unlikely to fully replace traditional mobile communications services domestically, or when roaming.

The following figures show that while they have had a substantial impact on the number of SMS in particular during the years 2012 and 2013 across Europe, additional increases in OTT usage subsequently had a less significant impact on the number of SMS in the majority of countries analysed, while the impact of OTT on telephony usage appears to have been even less pronounced. According to the latest WIK data, 97% of consumers have made or received at least one voice call over mobile or fixed networks in last month, while close to 60% have sent or received an SMS.[29]. The latest data for Germany also shows a stagnation in the number of users of interpersonal communications services offered by OTT players as well as a corresponding stagnation in the number of users who only use telephony and SMS offered by fixed and mobile operators.[30]

29 Arnold, René & Taş, Serpil. Auswirkung der Nutzung von OTT-1-Diensten auf das Kommunikationsverhalten – eine nachfrageseitige Betrachtung. WIK Diskussionsbeitrag Nr. 440. Bad Honnef: WIK.

30 Arnold, René & Taş, Serpil. Auswirkung der Nutzung von OTT-1-Diensten auf das Kommunikationsverhalten – eine nachfrageseitige Betrachtung. WIK Diskussionsbeitrag Nr. 440. Bad Honnef: WIK.

Figure 2-7: Evolution of SMS, Telephony and OTT use in European countries (growth relative to the year 2013)



Source: WIK estimate based on data provided by Ofcom, NRAs, GWI and OECD. Individuals above age 15.

There could be various reasons for the continued reliance on managed communication services, in the presence of attractive OTT offers.

One explanation could be that a core of customers are wedded to legacy services and/or lack smartphones or a mobile Internet connection. A 2018 study by the GSMA found that mobile Internet penetration was 72% in 2017. It projected that the gap would close, but suggests that 18% of mobile phone users would still lack mobile Internet access in 2025.[31]

Another constraint on the replacement of traditional mobile services with OTT could be that certain types of calls or messages require *any-to-any connectivity*. The lack of interoperability for most OTT services contrasts with the built-in interoperability offered with integrated mobile communications. Thus, even if OTT might become a replacement for mobile communications over time for certain communications (for example between close family members and friends), other communications which require interoperability such as business communications or communications between more remote contacts, would probably continue to rely on services provided by a mobile operator, or interconnection with those services (as for example in the case of SkypeOut).[32]

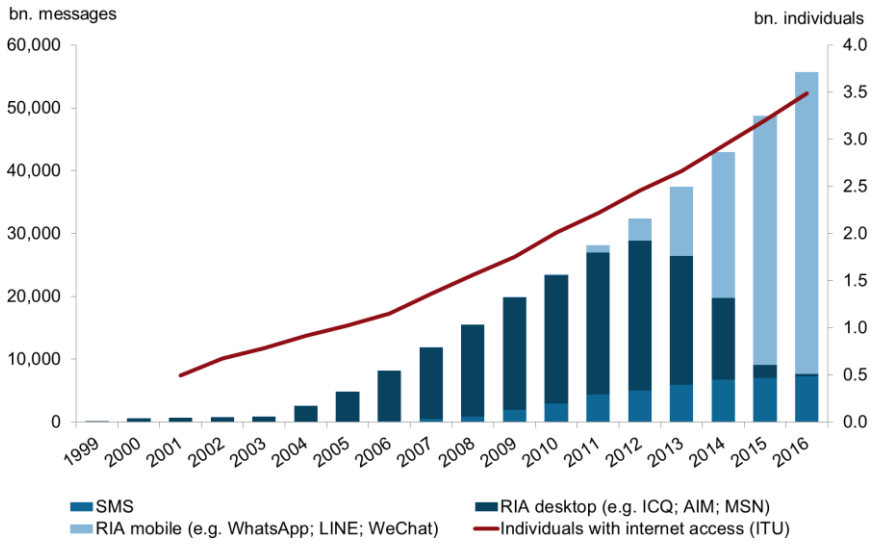
Another factor could be the distinct history of OTT, whereby OTT services primarily descend from interactive desktop applications. For example, Figure 2-8 shows that some of the most popular mobile-based communication services today gained significant popularity between 2012 and 2013.[33] The figure suggests that the majority of messages sent via mobile OTT messaging services would have otherwise been sent via desktop-based OTT messaging services.

31 GSMA (2018) The mobile economy.

32 Kroon, Peter, & René Arnold. 2018. Die Bedeutung von Interoperabilität in der digitalen Welt: Neue Herausforderungen in der interpersonellen Kommunikation – WIK Diskussionsbeitrag Nr. 437. Bad Honnef: WIK.

33 Arnold et al. 2017. The Economic and Societal Value of Rich Interaction Applications (RIAs). Bad Honnef: WIK.

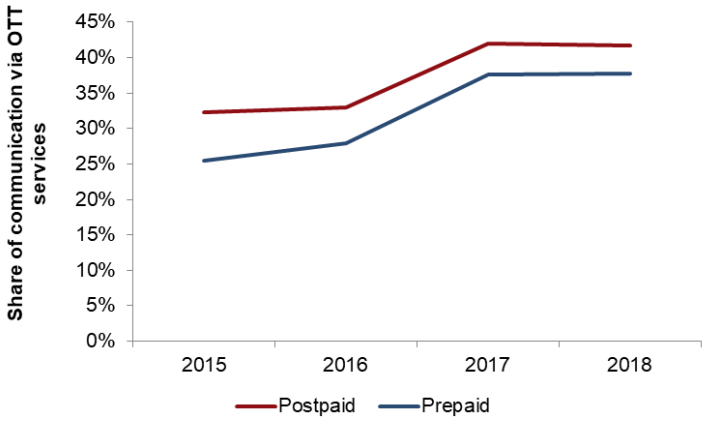
Figure 2-8: Number of SMS and OTT messages sent annually (worldwide in billion messages, individuals with Internet access in billion)



Source: Arnold et al. (2017).

A further dependency which may constrain the potential for OTT to fully replace integrated mobile communications is that some of the richer OTT applications such as video calling and file sharing rely on a *cost-effective high quality* data connection. This may explain the potentially counterintuitive finding in Germany (see figure below) that prepaid SIM customers which are likely to have faced higher call and messaging charges, nonetheless tend to use OTT services for a lower portion of their overall interpersonal long distance communication than postpaid subscribers benefiting from call and messaging bundles (Figure 2-9).

Figure 2-9 : OTT usage – postpaid vs prepaid in Germany



Source: WIK presentation based on WIK data.

The use of OTT by postpaid customers in preference to bundled minutes may also point to the fact that they may have been attracted by the added features and functions that OTT services offer.[34] These additional functions have changed the concept of interpersonal communications towards mixed usage of text, voice, pictures and videos,[35] and the frequency and nature of communications. By introducing more bandwidth intensive applications into the communications mix, OTT messaging services have also contributed to increasing the demand for and reliance on mobile data.

The importance of high quality data connections to support the full functionality of OTT services means that customers today are likely to seek out Wi-Fi connections when utilitising OTT, and would be even more likely to do so when roaming, if mobile data charges were raised above those charged domestically (as might occur in the absence of regulated data roaming). However, given the limited coverage of Wi-Fi (see discussion in Section 2.1.1), this means that in practice, richer OTT services (including Wi-Fi-based communications services integrated within the handset which are provided independently of the mobile operator such as Apple Facetime) cannot provide a substitute for voice and SMS roaming, at least in Europe[36] in the short term.

However, as discussed in Section 2.1.1, it is possible that consumer behavior might change and reliance on OTT services increase if high quality mobile data packages are offered at an attractive rate and with high or unlimited data caps, including while roaming. For example, large data allowances, and the integration of Wi-Fi offloading within the data service, could become a feature of 5G offers. Moreover, although interoperability could limit the degree to which OTT services can become functional substitutes for managed communication services beyond close contacts, it is possible that the risk of losing further traffic to OTT services serving closed user groups, as well as competition from OTT originated communication services such as Skype, could constrain the degree to which mobile operators could profitably raise prices for

34 Arnold, René, & Anna Schneider. 2017. "The Functionalities of Success: A Psychological Exploration of Mobile Messenger Apps Success." TPRC45, Arlington, VA, 8.-9. September, 2017.; Arnold, René, Anna Schneider, & Christian Hildebrandt. 2016. "All Communications Services Are Not Created Equal – Substitution of OTT Communications Services for ECS from a Consumer Perspective." TPRC44, Arlington, VA, 30. September - 01. October, 2016.; Brubaker, Jed R., Gina Venolia, & John C. Tang. 2012. "Focusing on Shared Experiences: Moving beyond the Camera in Video Communication." Designing Interactive Systems Conference, Newcastle Upon Tyne, 11.-15. June, 2012.; Church, Karen, & Rodrigo de Oliveira. 2013. "What's Up with WhatsApp?: Comparing Mobile Instant Messaging Behaviors with Traditional SMS." 15th International Conference on Human-Computer Interaction with Mobile Devices and Services, Munich, 30. August, 2013.; O'Hara, Kenton, Alison Black, & Matthew Lipson. 2006. "Everyday practices with mobile video telephony." Conference on Human Factors in Computing Systems, Montréal, 22.-27. April, 2006.; O'Hara, Kenton, Michael Massimi, Richard Harper, Simon Rubens, & Jessica Morris. 2014. "Everyday dwelling with WhatsApp." 17th Conference on Computer Supported Cooperative Work & Social Computing, Baltimore, MD, 15.-19. February, 2014.

35 For an overview see Arnold, René & Serpil Taş. Auswirkungen von OTT-1-Diensten auf das Kommunikationsverhalten – Eine nachfrageseitige Betrachtung. WIK Diskussionsbeitrag Nr. 440. Bad Honnef: WIK.

36 It may already be a substitute in other countries, where data roaming charges are higher and cost considerations more acute.

originating calls and messages, implying that they could be considered to be in the same relevant market.

The inclusion of both types of services in the same relevant market could also be affected by the introduction by mobile operators of rich applications that are more similar in functionality to existing OTT services, making the services appear more equivalent from a consumer perspective. This is discussed in the following section.

2.1.3 Rich Communications Services

Rich Communications Services (RCS) have been positioned by mobile operators as the next generation of SMS and voice services. They are intended to provide additional functionality, which may in some cases mirror the functionalities available via OTT applications, and should facilitate the migration from traditional network structures to all-IP networks as well as the convergence of mobile and fixed services. Thus, they may reduce the relevance of or require adaptations to traditional voice and SMS roaming.

Rich Communications Services (RCS)[37] were originally conceived as the evolution of SMS. RCS was developed within GSMA towards the end of the 2000s[38] as an advanced messaging service based on the IP Multimedia Subsystem (IMS). While the first introduction of RCS by various mobile operators around 2012 was not successful, Google's recent push to introduce RCS as "Chat" on Android devices may be a more promising attempt to establish RCS as a new 'default' messaging service. For RCS to function both the sender as well as the recipient need to have a device which is RCS ready, a RCS client and have to be subscribed to an operator enabling RCS. If one of these requirements is not meet RCS messages cannot be sent or received. To date, 75 operators worldwide has launched RCS. GSMA forecasts that within a year another 40 operator will implement RCS.[39]

One clear distinction between RCS and OTT (which provides advantages for some applications as discussed above) is that, like mobile telephony and SMS today, it is designed to be interoperable across mobile network operators. With additional functions such as video calls[40], RCS also provides an evolution to traditional voice calls that could enable mobile operators to provide services that compete with the expanding OTT video-calling segment.

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37 GSMA. 2018. RCS Universal Profile Service Definition Document - Version 2.3. Note: RCS are also known as "joyn", "message+", "SMS+" or "advanced messaging".

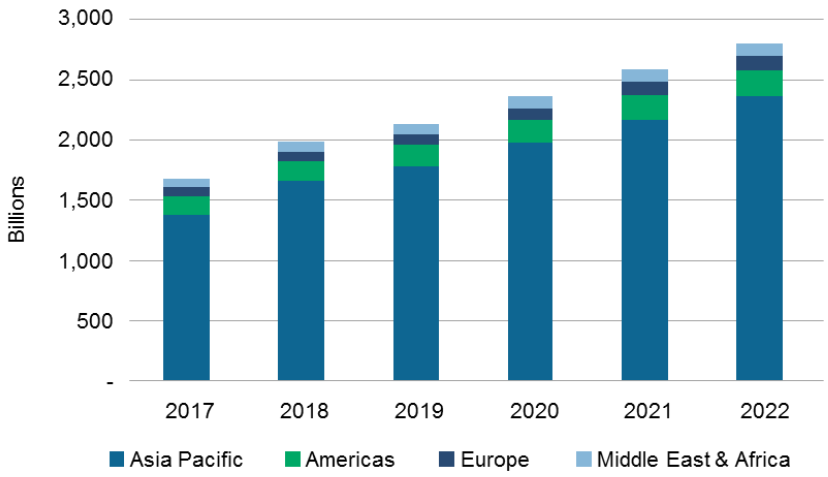
38 Release 1 of the Rich Communication Suite was in 2008.

39 https://www.gsma.com/futurenetworks/rcs/global-launches/.

40 In total, the universal profile defines ten functions for RCS: (1) Standalone Messaging, (2) 1-2-1 Chat, (3) Group Chat, (4) File Transfer, (5) Content Sharing, (6) Social Presence Information, (7) IP Voice call, (8) IP Video call, (9) Geolocation Exchange, (10) Capability Exchange based on Presence or SIP OPTIONS.

Another business opportunity for mobile operators that could be expanded by RCS is Application-to-Person (A2P)[41] messaging, which is currently still operated using SMS although WhatsApp (WhatsApp Business) and Viber have recently begun to offer competing services. The volume of A2P messages has been growing globally. Analysts expect this growth to continue for the foreseeable future because with the additional functions that RCS offer, this kind of customer interaction will likely become more attractive to commercial clients than previous opportunities available via SMS.

Figure 2-10: Total global A2P SMS messages by region (2017-22)[42]



Source: mobilesquared.

Since RCS is essentially a number-based interpersonal communications service[43] and a SIM-Card is mandatory for the authentification procedure as well as the distribution of messages, it can be expected that mobile operators will retain a relatively strong link to the RCS featured on their customers' devices both domestically and when roaming. Furthermore, SMS is still foreseen as the fallback. Thus, in both Peer-to-Peer (P2P) and A2P messaging use cases, RCS is unlikely to constitute a significant roaming bypass. In fact, as commercial clients may seek to interact with consumers either through human agents or AI chatbots, RCS is more likely to increase roaming traffic than to decrease it.

As IP-based interoperable mobile communication services such as RCS, and VoLTE, which is in the process of being introduced, require interconnection agreements, and

41 GSMA. 2017. Messaging as a Platform - The Operator Opportunity.

42 The analysts at mobilesquared expect RCS on (only) Android devices "to remove 194.34 billion messages from white-route A2P SMS traffic in in 2022, while RCS clients on all smartphones would reduce total white traffic volume by 237.99 billion." (see https://mobilesquared.co.uk/2018/02/18/global-a2p-traffic-growth-by-2022/).

43 It is not entirely clear how multi-client and multi-device functionalities of RCS will be categorized under the European Electronic Communications Code (EECC).

agreements which would allow roaming for cross-border traffic, it is not clear that they would significantly affect change the competitive dynamics for roaming at a wholesale level compared with the current dynamics associated with traditional voice and SMP. However, they may require new standards and commercial models to be developed, which might require roaming regulation to be updated in the event that bottlenecks persist following their introduction. Roaming regulation adapted to RCS and VoLTE might be necessary in the event that OTT does not provide sufficient competitive constraint to render a price increase in such services unprofitable and/or if there could be a risk that interoperability would be denied, impacting the potential for competition in retail markets.

2.2 Technological developments and platforms facilitating competition in mobile roaming services

As discussed in Section 2.1.1, it seems unlikely that Wi-Fi will provide a full substitute for mobile data roaming. When considering developments which impact competition in roaming markets, it is therefore important to consider the potential for new technologies to facilitate competition in mobile roaming itself.

It has always been possible for customers to avoid or limit roaming charges by switching to a local operator on arrival at their destination, or by using a specialist operator targeting the roaming segment. However, customers have historically faced barriers to switching due to the need to use a separate physical SIM card.

To address this challenge, some handsets have been developed to accommodate multiple SIM cards. However, these are likely to be used only by business users or consumers with significant travel requirements outside of the EU/EEA, leaving other customers reliant on their home operator's service, which might be subject to excessive charges if not regulated. [44]

Technologies are however evolving to address this switching challenge – which affects not only human customers, but also connected things. The main developments thus far are for virtual SIMs and embedded SIMs, which offer the potential for remote switching.

44 Solutions such as multi-SIM phones continue to be widely used in some developing countries, where roaming charges for voice calls can sometimes exceed €2 per minute. Prior to the introduction of the first EU Roaming Regulation in 2007, they were sometimes used in Europe. We expect that they are quite rare in the EU/EEA today, because there is no longer a cost incentive that could outweigh the inconvenience. Similarly in some developing countries multi-SIM phones have also been used to avoid high domestic off-net charges that can be associated with high termination rates.

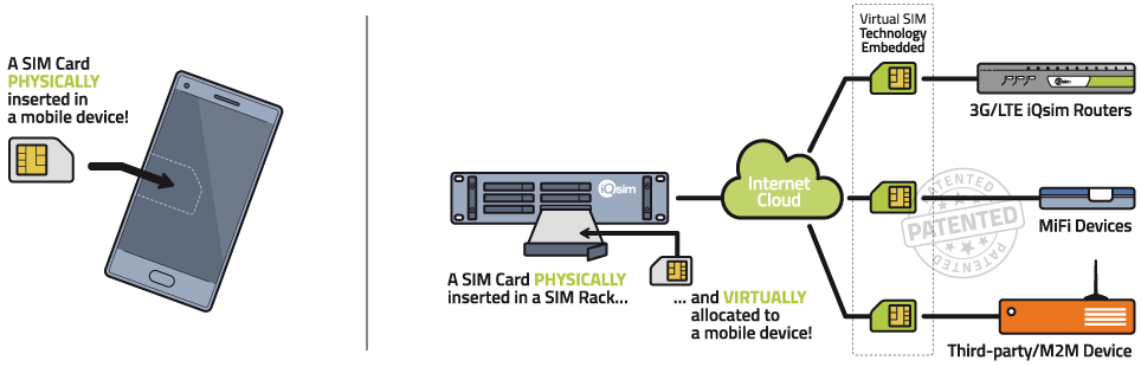
2.2.1 Virtual SIM

The development of the virtual SIM derived from the idea to download data remotely to the memory of a handset via a secure channel. For this solution, the SIM card itself remains in its place, but has the function of a “dummy” that contains no data at all and has a memory that can be rewritten.[45] Therefore, the virtual SIM enables to share SIM cards across multiple devices and allows the consumer to make use of the most appropriate SIM card case-by-case.

Overall, the virtual SIM can be regarded as a predecessor of the eSIM, as the eSIM goes one step further and does not require a “dummy” to download data directly into the memory of the phone/device.

Virtual SIM technologies can involve placing a physical SIM card remotely in a SIM rack – and enabling a virtual connection through the cloud to different devices, each of which would need to be installed with a SIM card with virtual SIM technology (see Figure 2-11).

Figure 2-11: Example of virtual SIM technology



Source: iQsim.

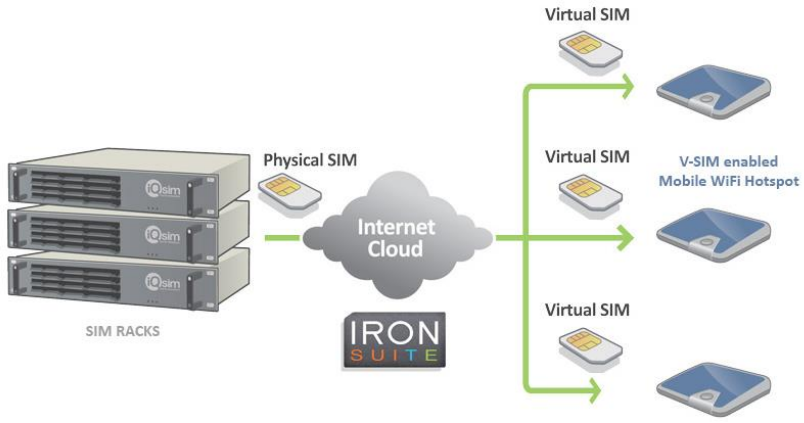
Different business models have been implemented so far with regard to the Virtual Sim which involve varying solutions and devices:

An example of this set-up from French company ***iQsim*** is shown in the diagram below (see Figure 2-12). Based on this technical solution, different services are provided, among them data roaming for business travellers, mobile testing, mobile communication and IoT/M2M SIM card provisioning/deployment (see https://www.iqsim.com).

45 See for example Shatlin, I (2016): What are virtual SIM cards and what do they do? March 16, 2016, Kaspersky blog: https://www.kaspersky.com/blog/virtual-sim/11572/.

With regard to data services for roamers, iQsim solution is offered at VSIM-enabled Wi-Fi hotspots. The solutions are composed of a software structure (IRON Suite software infrastructure), which manages devices and SIM cards, SIM racks which stores physical local SIM cards and VSIM-enabled Mobile WiFi hotspots (see Figure 2-12). At a VSIM-enabled Mobile WiFi hotspot, travellers switch on their mobile hotspot and a SIM card is allocated dynamically to the device based on the hotspot location.

Figure 2-12: Virtual SIM solution: iQsim



Source: iQsim, https://www.iqsim.com/en/Solutions/1-Data-Roaming.htm.

Another example of a European (UK-based) company using virtual SIM technology is ***TEP Wireless***. Their service is provided through a pocket WiFi device ("Teppy", see Figure 2-13), which can be delivered before a trip or picked up at airports. This device works similar to a wireless router at home and creates a wireless hotspot which anyone in the vicinity can connect to by using a password (https://www.tepwireless.com/faq/rent). The WiFi device is connected through partnerships reached with mobile network operators across multiple countries.

Figure 2-13: Virtual SIM example: TEP Wireless Pocket WiFi device

Source: TEP Wireless.

Other virtual SIM players which have been targeting North American and other consumers, who do not benefit from regulated roaming rates, include Knowroaming and Glocalme. For example, Knowroaming offers a 'Global SIM card' and 'Global SIM sticker' (attached to an existing SIM). They claim their services enable savings of 85% off international voice and data roaming in more than 200 countries. Glocalme implements its roaming solutions via a SIMBOX (see https://www.glocalme.com/simbox/poster?lang=en-US&giso=DE).

All these services seem to be still in operation, but no information about their uptake is available. It can be assumed that they might have attracted some specific target groups, but have not made significant headway in the mass market. As already indicated above, Virtual SIM can be regarded as the forerunner of Embedded SIM (eSIM), and is likely to be superseded within the 5-10 year timeframe which is the subject of analysis for this study.

2.2.2 Embedded SIM (eSIM)

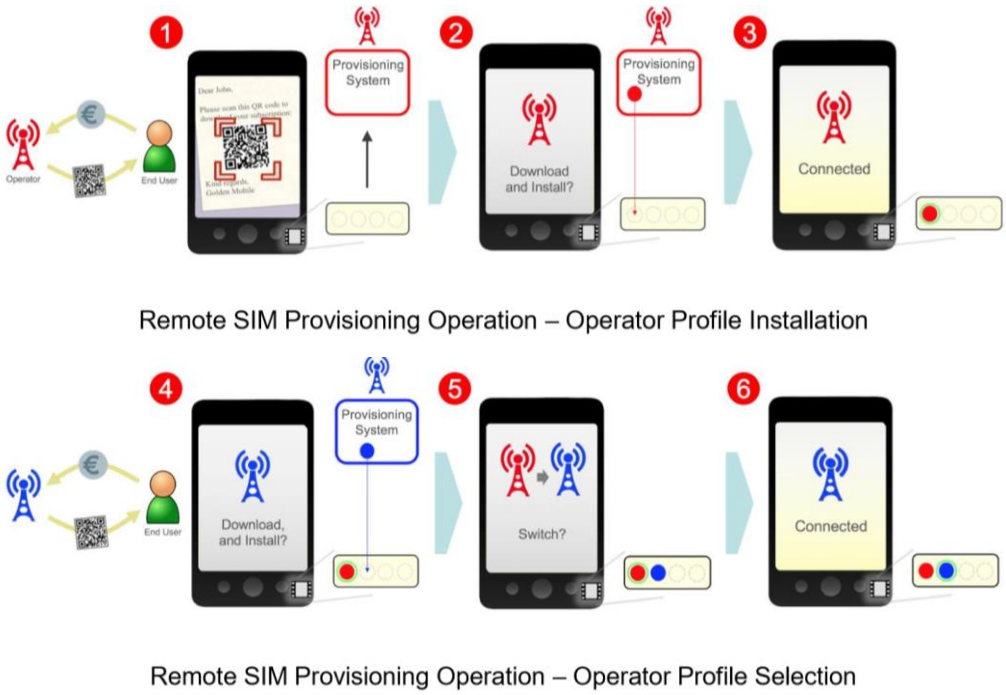
2.2.2.1 Characteristics and technical basics

The embedded SIM (eSIM)[46] can be considered the next stage of development in the area of the SIM card. There is no unique definition of eSIM and various interpretations exist across the industry. However, some key principles apply.

The main difference compared with traditional SIM cards is the capability for remote SIM provisioning which allows operator switching without changing the SIM card (see Figure 2-14).

46 Often also referred to as eUICC, i.e. Embedded Universal Integrated Circuit Card which is in a narrower sense the secure element in the eSIM solution, see GSMA (2018): eSIM Whitepaper - The what and how of Remote SIM Provisioning, March 2018, https://www.gsma.com/esim/wp-content/uploads/2018/06/eSIM-Whitepaper-v4.11.pdf, page 6.

Figure 2-14: Remote SIM provisioning operation process (for consumer solutions)



Source: GSMA (2018).[47]

Another distinguishing feature compared with previous SIM cards is that it can be soldered inside the mobile device. However, according to GSMA this is not necessarily required.

Whether firmly installed or not, the eSIM can accommodate multiple SIM profiles – thereby facilitating wider availability of the multi-SIM capabilities that are present in some devices today. However, under the GSMA specification, multiple profiles cannot be active at the same time, but only one, which represents a barrier to their flexibility of use.

Each SIM contains the operator and subscriber data that would have otherwise been stored on a traditional SIM card.[48] Profiles are downloaded remotely over-the-air. They remain the property of the operator as it contains items "owned" by them, e.g. IMSI, security algorithms, and supplied under the related licence. While the general concept of eSIM is simple, its implementation process is complex and requires extensive resources to enable mobile connectivity providers to test and adopt the related business processes. Most smaller players, e.g. national MVNOs, have not yet deployed eSIM.

47 See GSMA (2018): eSIM Whitepaper - The what and how of Remote SIM Provisioning, March 2018, https://www.gsma.com/esim/wp-content/uploads/2018/06/eSIM-Whitepaper-v4.11.pdf, page 5-6.

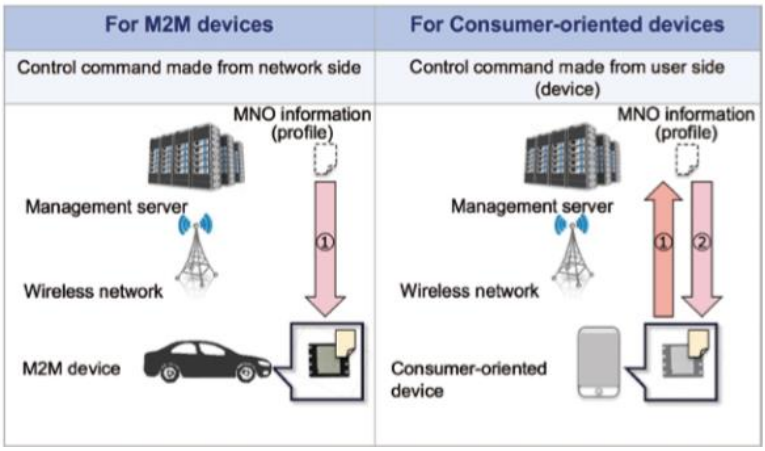
48 See for any further details with regard to the GSMA definition GSMA (2018): eSIM Whitepaper - The what and how of Remote SIM Provisioning, March 2018, https://www.gsma.com/esim/wp-content/uploads/2018/06/eSIM-Whitepaper-v4.11.pdf, page 5.

The remote SIM provisioning process involves new solutions for subscription management (according to the GSMA specification two new roles: SM-DP DP (Subscription Manager - Data Preparation) and the SM-SR (Subscription Manager - Secure Routing).[49] Among the providers offering these solutions are SIM manufacturers such as Gemalto, Giesecke&Devrient and Oberthur. However, this role could also be taken by a provider itself (for example GigSky and Truphone). If subscription management is not transferred to an independent player, there could be the risk of "closed systems" with barriers to switching, even in cases where the implemented systems are almost compatible with the GSMA specification.

While the basics of the eSIM solution are similar for both M2M and consumer applications, the consumer solution requires the management of more complex use cases than M2M. This is due to the fact that a human is involved in the consumer solution, but not in M2M. As a consequence, more features need to considered. This includes the interaction of the end user via the mobile device end user interface as well as standalone and companion device types.[50]

The most significant difference between eSIM solutions for M2M and for consumers is whether the rewriting is initiated from the network side, i.e. MNO, or from the device side, i.e. the user (see Figure 2-15).

Figure 2-15: eSIM – differences in the implementation process for M2M and consumer devices



Source: Tsurusawa (2017).[51]

49 See GSMA (2017): RSP Architecture V2.2, 01 September 2017, https://www.gsma.com/newsroom/wp-content/uploads//SGP.21_v2.2.pdf, page 16.

50 See GSMA (2018): eSIM Whitepaper - The what and how of Remote SIM Provisioning, March 2018, https://www.gsma.com/esim/wp-content/uploads/2018/06/eSIM-Whitepaper-v4.11.pdf, page 9.

51 See Tsurusawa, M. (2017): Latest Trends in Remote SIM Provisioning Technology, in: New Breeze, Summer 2017, https://www.ituaj.jp/wp-content/uploads/2017/08/nb29-3_web-01-SpecialRemoteSIM.pdf, page 3.

Standardisation processes for eSIM date back to 2011 and have been mainly driven by the GSMA (GSM Association).

Within the framework of the GSMA, in which about 800 mobile network operators and 300 companies worldwide, including mobile-related hardware and software sectors, are members, the technical specifications for a standardized eSIM have been developed on a broad basis. Therefore, a number of major carriers have declared support for the new technology, including AT&T, Deutsche Telekom, Etisalat, Hutchison Whampoa, Orange, Telefónica and Vodafone. A first architecture for eSIM in M2M was published by the GSMA in December 2013.[52] A separate specification for the consumer sector was released in October 2016.[53] Meanwhile, uniform technical architectures and interfaces have been developed for both areas. However, the GSMA specification is constantly evolving.[54]

eSIM offers the same capabilities in relation to traditional data, voice and SMS services as traditional SIM. It might be argued that the eSIM involves more security risks than the traditional SIM due to the remote programming requirement. With regard to roaming, eSIM might facilitate the use of alternative offers compared with traditional SIM cards. It could also simplify the process of providing alternative roaming offers, as no specific SIM cards need to be created. From a consumer perspective, it would be more easy to access offers of local operators in a visited country as no local SIM need to be purchased, the existing SIM card does not need to be changed and the consumer can still be reached under its home number. For M2M use cases with long lifetime, provider changes can be conducted without changing the SIM card (which is often not easy to access in machines).

The practical implications of eSIM on roaming markets will depend on the pace of deployment and activation, as well as on the ease of the multi-profile and switching process for end-users. These issues are explored in the following sections, alongside examples of the implementation of eSIM for consumer, business and M2M markets.

52 See GSMA (2014): Benefits Analysis of GSMA Embedded SIM Specification on the Mobile Enabled M2M Industry, https://www.gsma.com/iot/wp-content/uploads/2014/10/Benefits-Analysis-GSMA-Embedded-SIM-Specification.pdf, page 3.

53 See GSMA (2015): RSP Technical Specification Version 2.0 14 October 2016, https://www.gsma.com/newsroom/wp-content/uploads/SGP.22_v2.0.pdf.

54 The current GSMA specification in version 2.2.1 of December 2018 is available at https://www.gsma.com/newsroom/all-documents/sgp-22-technical-specification-v2-2-1/.

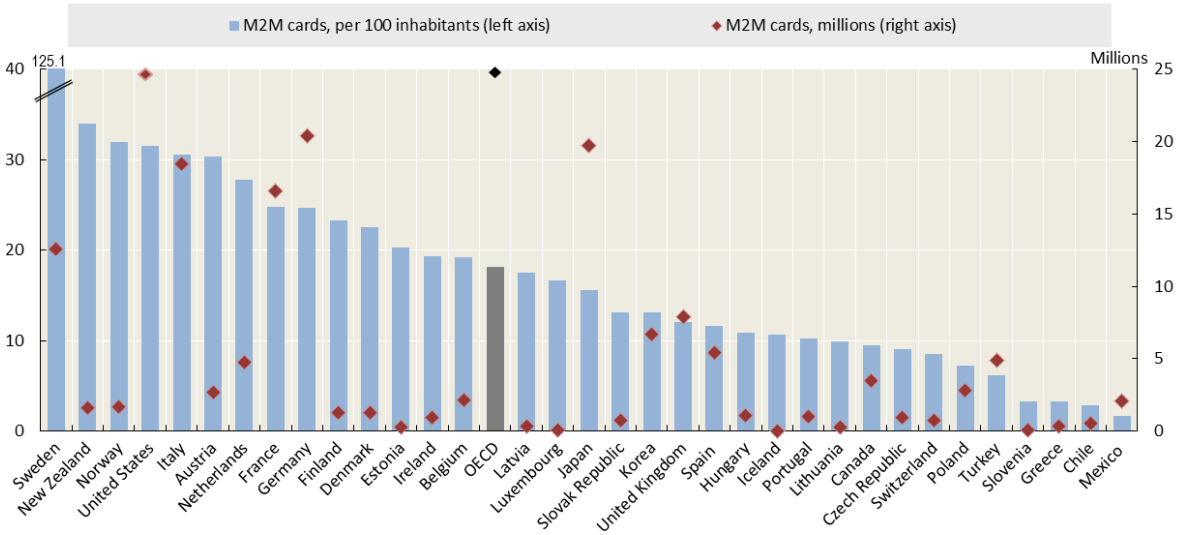
2.2.2.2 Current eSIM offers

2.2.2.2.1 M2M

For M2M applications, specific M2M SIM cards (Machine Identification Module (MIM)) – smaller and more suitable for long life in extreme conditions than traditional SIM - have been developed and are implemented in various use cases such as smart buildings, smart manufacturing, smart energy, tracking and tracing and connected cars.[55]

OECD reports that in June 2018 about 244 million M2M cards have been deployed in OECD countries. However, there are significant differences in M2M card penetration between the countries(see Figure 2-16). The most advanced European countries for M2M take-up include Sweden, Norway and Italy.

Figure 2-16: M2M subscriptions, June 2018



Source: OECD.[56]

eSIM offers significant advantages compared with other formats. However, eSIM is most useful for applications which require a remote update of settings. For these reasons, the deployment of eSIM for M2M has proven to be very efficient in solving logistics issues, and in allowing devices to cross borders seamlessly without disruption for the end user.[57] It is implemented for various use cases, including connected cars and the utility sector (see Table 2-1):

55 See Gemalto, https://www.gemalto.com/m2m/solutions/mim.
56 See OECD, www.oecd.org/sti/broadband/1.12-M2M-2018-06.xls.
57 See e.g. Spanjaard, T. (2018): Consumer eSIM not likely to happen soon!, 1 May 2018, in: Smart Insights, https://www.smartinsights.net/single-post/2018/05/07/Consumer-eSIM-not-likely-to-happen-soon.

Table 2-1: Use cases for M2M

Category	Emerging use case	Most suitable type of SIM	Industries likely to benefit the most	Devices likely to benefit	Merits of the SIM
Cellular connectivity	**Machine/device authentication and connectivity in the IoT market**	Reprogrammable embedded for some use cases. Any type of SIM for other use cases	• Automotive • Utilities • Healthcare • Agriculture	• Connected cars • Smart meters • Sensors	• Wide coverage • Ultra reliability
Value-added services	**Mobile- based digital identity and authorisation**	Any SIM (reprogrammable or non-reprogrammable; removable or embedded)	• Public administration • Public transportation • Banking, finance, insurance • Healthcare • Education	• Handsets • Wearables	• Security • Wide coverage • Wide adoption

Source: GSMA (2017): https://www.gsmaintelligence.com/research/?file=3f8f4057fdd7832b0b923cb051cb6e2c&download.

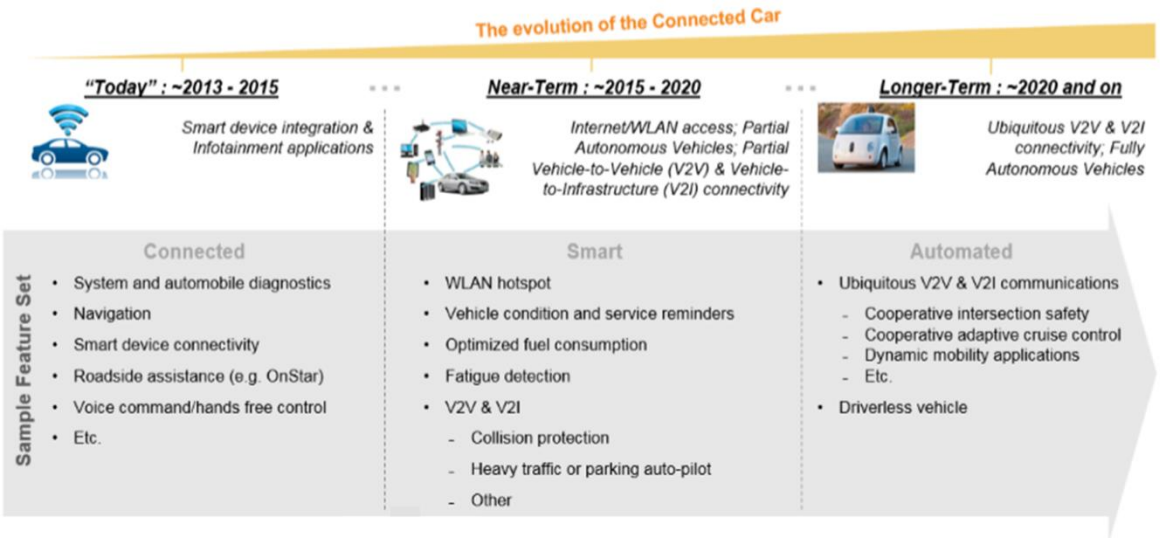
Various players have benefited from eSIM in the M2M segment. According to "Research and Markets" major players include: Deutsche Telekom AG (Germany), Gemalto NV (Netherlands), Giesecke & Devrient GmbH (Germany), Infineon Technologies AG (Germany), NTT DOCOMO, INC. (Japan), NXP Semiconductors N.V. (Netherlands), Sierra Wireless, Inc. (Canada), Singapore Telecommunications Limited (Singapore), STMicroelectronics (Switzerland), and Telefonica, S.A. (Spain).[58] However, it also offers business opportunities for various smaller and specialized M2M players like e.g. Datamobile AG, Liechtenstein (http://www.datamobile.ag/esim/).

Market experts agree that connected cars are the most developed segment of M2M and highly relevant for eSIM. According to GSMA, some predictions suggest that one in five vehicles will have a wireless network connection by 2020, accounting for more than 25% of a billion cars on roads globally.[59]

58 See Research and Markets (2018): $978 Million eSIM Market by Application, Vertical, and Geography - Global Forecast to 2023, 3 April 2018, https://www.prnewswire.com/news-releases/978-million-esim-market-by-application-vertical-and-geography---global-forecast-to-2023-300623446.html.

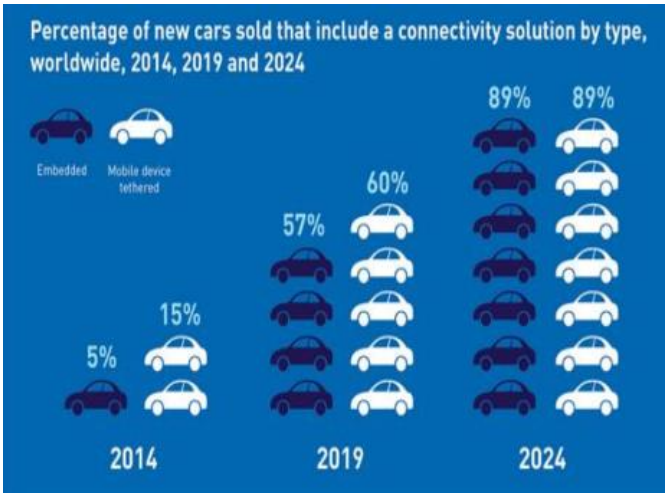
59 See GSMA (2016): Emerging Trends & Market Predictions, https://www.gsma.com/iot/wp-content/uploads/2016/09/Connected-car-emerging-trends-and-market-predictions.pdf, slide 3.

Figure 2-17: Market phases of connected car



Source: GSMA.[60]

Figure 2-18: Development of connectivity in cars (2014-2024)



Source: GSMA.[61]

60 See GSMA (2016): Emerging Trends & Market Predictions, https://www.gsma.com/iot/wp-content/uploads/2016/09/Connected-car-emerging-trends-and-market-predictions.pdf, slide 2.

61 See GSMA (2016): Emerging Trends & Market Predictions, https://www.gsma.com/iot/wp-content/uploads/2016/09/Connected-car-emerging-trends-and-market-predictions.pdf, slide 4.

There are some overlaps between M2M and consumer IoT, which have become most evident in relation to connected car. In principle, a distinction can be drawn whereby a human is involved in a consumer solution, but not in M2M. However, there is a “grey” area in cases such as connected cars, which involve M2M as well as personal communications. Such cases can raise questions about application of rules relating to permanent roaming (see Section 2.2.2.6).

2.2.2.2.2 B2C

As regards consumers, the most significant benefits of eSIM include:

- Remote ‘over-the-air’ SIM provision on any mobile device offers the potential to significantly reduce switching barriers.
- Moreover, it has the potential to enable direct connectivity for smaller devices such as tablets, smart watches, fitness bands, personal trackers and portable health systems.
- In addition, multi-device-contracts can be developed, offering a single contract for several devices.
- eSIM can also facilitate the use of alternative roaming services by consumers, although there are currently some limitations (see Section 2.2.2.4).

The development of eSIM for the consumer segment has been primarily driven by manufacturers such as Apple and Samsung.

Apple first introduced the iPad in 2010 and launched its tablet iPad Air 2 with an Apple SIM embedded in 2013. Today, Apple offers its iPad with different models and sizes. The third generation of iPad Pro is equipped with eSIM. Apple has pursued a number of approaches to provide cellular capabilities in its tablets – some are preinstalled, some are removable and some are eSIM (see Table 2-2).[62] Based on available data, it is not possible to indicate the number of eSIM-equipped iPads, but their share in the total installed base today seems to be relatively low.

62 See information about the Apple SIM at https://www.apple.com/ipad/cellular/.

Table 2-2: Overview on eSIM in Apple iPad

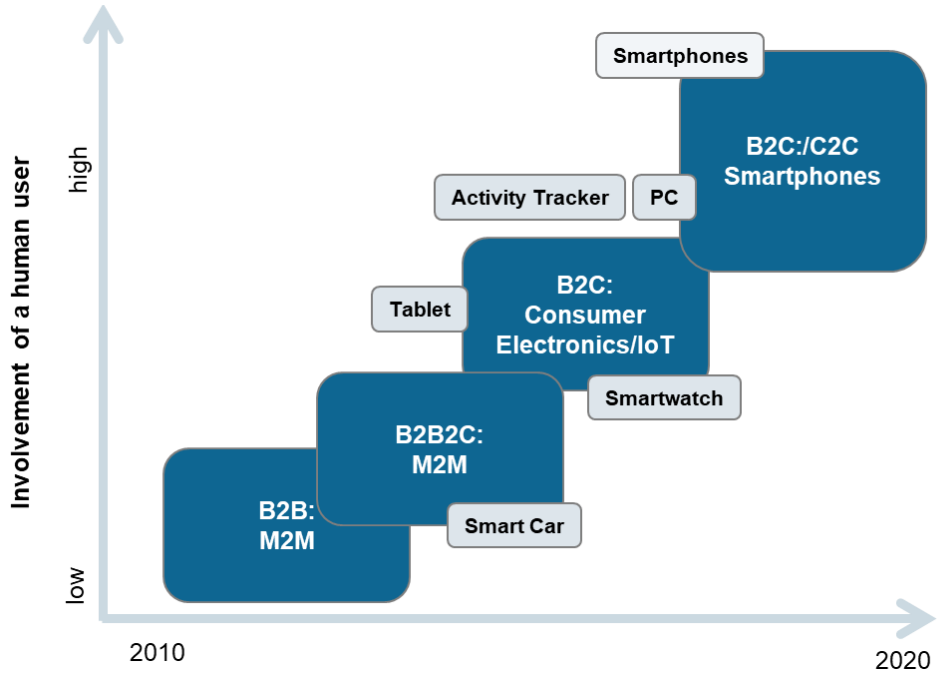
	eSIM	Apple SIM Included	Apple SIM Embedded
11-inch iPad Pro	✓		
12.9-inch iPad Pro (3rd gen.)	✓		
12.9-inch iPad Pro (2nd gen.)			✓
12.9-inch iPad Pro (1st gen.)		✓	
10.5-inch iPad Pro			✓
9.7-inch iPad Pro			✓
iPad (6th gen.)		✓	
iPad (5th gen.)		✓	
iPad Air 2		✓	
iPad mini 4		✓	
iPad mini 3		✓	

Source: Apple.[63]

Connectivity for the Apple SIM is available in 180 countries and regions. The location of the users is identified automatically and a selection between available providers is given. Besides data access from GigSky[64] and Always Online,[65] Apple has contracts with several MNOs. However, not all MNOs in a country support eSIM. For example, in Germany, only Deutsche Telekom supports eSIM. Therefore, the choice and switching options for consumers are limited.

63 https://www.apple.com/ipad/cellular/.
64 See https://www.gigsky.com/?gclid=EAIaIQobChMIn4iUx9yA1QIVxzLTCh2tGQPxEAAYASAAEgJUw_D_BwE.
65 See https://alwaysonlinewireless.com/apple-sim.

Figure 2-19: eSIM: product launch phases from M2M to Consumer



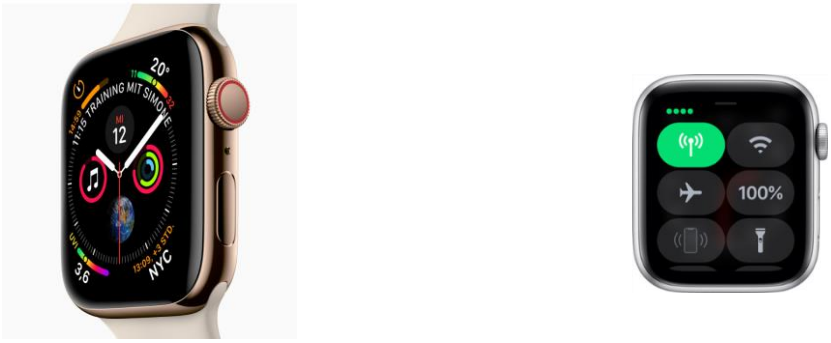
Source: WIK-Consult.

The next major step for consumer eSIM after the Apple SIM involved the launch of wearables, especially smartwatches (e.g. the Samsung Gear watch and the Apple watch).

In November 2016, Samsung launched its Smartwatch Samsung Gear S2 classic with eSIM. In September 2017, Apple equipped its Apple Watch 3 with an eSIM as well. Several other producers followed, e.g. LG, Huawei, as well as some smaller players.[66] Overall, SIM-equipped smartwatches are still "niche" products and seem to be less popular than smartwatches without SIM. Usability is still limited due to restrictions arising from the battery life. Therefore, current smartwatch models are not capable of completely replacing smartphones.

66 See e.g. https://www.smartgeekwrist.com/standalone-smartwatch-sim-card/.

Figure 2-20: Apple Watch with eSIM



Apple Watch Series 4

In September 2017, Apple Watch series 3 was equipped with eSIM. This smartwatch is able to switch seamlessly to cellular when it is away from the iPhone. It shares the same number as the iPhone. The user can make calls directly with Apple Watch Series 3 (GPS + Cellular). Former models required a companion device (i.e. an iPhone). **67**

Source: Apple.**68**

The launch of eSIM in smartphones is key to penetrating the consumer segment. It happened much later than many experts had expected; however, since it was promoted by both Google and Apple in 2017/2018, more device manufacturers can be expected to follow this strategy.

Google Pixel 2, the first smartphone with eSIM, launched in Autumn 2017. The devices were developed by HTC and LG and marketed by Google. One year later, Google Pixel 3 was launched with an eSIM as well. Google claims to be actively supporting the eSIM, e.g. it announced "To enable a consistent and simple experience across the ecosystem, we're also creating a program that allows Android device makers to build eSIM-capable smartphones. We look forward to continuing our work with our partners on the potential benefits of eSIM — whether that's getting you connected to a phone, watch, tablet, or laptop—in the future."**69** Google does not report any data about the number of Pixel smartphones sold; however, both premium smartphones can be assumed to play a niche role in the global smartphone market.

67 See Apple (2017): Apple Watch Series 3 brings built-in cellular, powerful new health and fitness enhancements, press release, 12 September 2017, https://www.apple.com/in/newsroom/2017/09/apple-watch-series-3-features-built-in-cellular-and-more/.

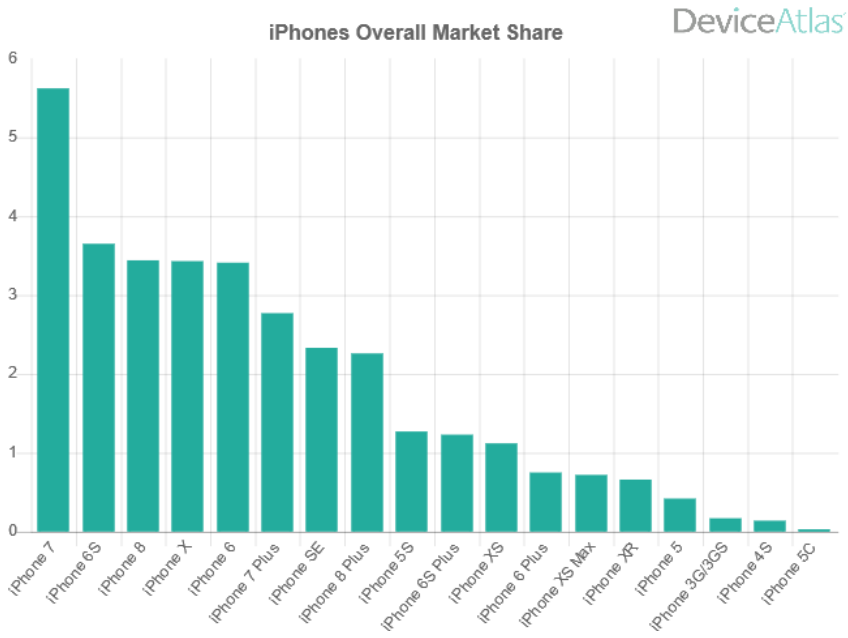
68 See https://www.apple.com/de/apple-watch-series-4/?afid=p238%7CsgO0Aww6R-dc_mtid_20925oze42631_pcrid_295721136696_&cid=wwa-de-kwgo-watch-slid---apple+watch-e-productid- and https://support.apple.com/en-us/HT207578

69 See Hogan, K. (2018): Bringing eSIM to more networks around the world - Dec 3, 2018, https://www.blog.google/products/project-fi/bringing-esim-more-networks-around-world/.

For this reason, the launch of eSIM in the iPhone in autumn 2018 can be regarded as a key development in light of the high market share of Apple in the smartphone market.

In September 2018, the new iPhone models iPhone XS, iPhone XS Max and iPhone XR were launched with eSIM.[70] However, their share among total iPhone models worldwide is still very low (less than 3%, see Figure 2-21).

Figure 2-21: iPhones – share of different models 2019



Source: Device Atlas.[71]

These smartphones feature dual SIM with a nano-SIM card and an eSIM.[72] This allows several options for usage, i.e. one number for business and another for personal use, separate plans for voice and data, and last but not least a local data plan in a visited country.

These options are also available with other dual-SIM phones using traditional, removable SIMs – they do not depend on eSIM. However, dual-SIM smartphones in general provide the advantage that the user/roamer can be reached via two numbers on the same phone at the same time, and is not obliged to change his or her number while roaming.

70 See Apple (2018): Apple Special Event. September 12, 2018, https://www.apple.com/lae/apple-events/september-2018/.

71 See https://deviceatlas.com/blog/most-popular-iphones.

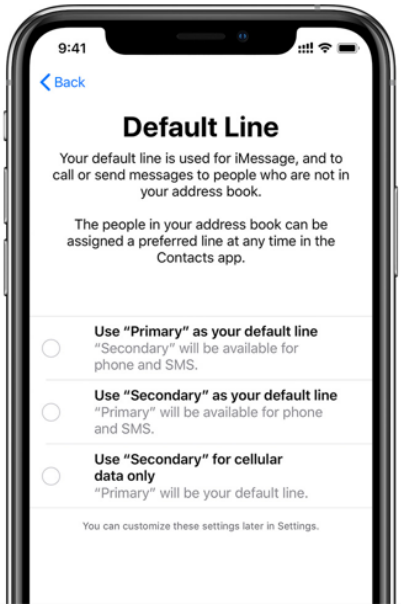
72 Until September 2018 and the launch of eSIM enabled phones, Apple did not offer any dual-SIM smartphones. By contrast, other smartphone producers like e.g. Huawei and Xiaomi have been offering a wide range of dual-SIM smartphones.

To activate the eSIM in the iPhone, the end user needs an activation code from his provider. This is currently available via different contact points and in different forms (online or by letter). For the use of eSIM in the iPhone, iOS 12.1 is required, which typically requires an update. An additional line and a corresponding mobile phone tariff for the eSIM can then be added in the menu under “settings to the mobile network”.

Several profiles can be stored on the eSIM; however, they cannot be used simultaneously, but only alternately. At any given time, the user must set one of the active ports through the menu as being the "default line" (see Figure 2-22). This functionality allows switching between different providers.

Apple notes on its support site that the “secondary for cellular data only” option could be useful if you are travelling internationally and want to use your Primary MNO for voice, SMS, iMessage and FaceTime. Secondary would then be used for data (see Figure 2-23). Other interviewees suggested setting the home network operator (on the traditional SIM) as secondary, and using the secondary (i.e. home) MNO only for receiving calls and SMS messages.

Figure 2-22: eSIM in the iPhone – choose a default line



Use Primary as your default line: If you select this option, Primary will be used by default for voice, SMS, Data, iMessage, and FaceTime. Secondary will be available just for voice and SMS.

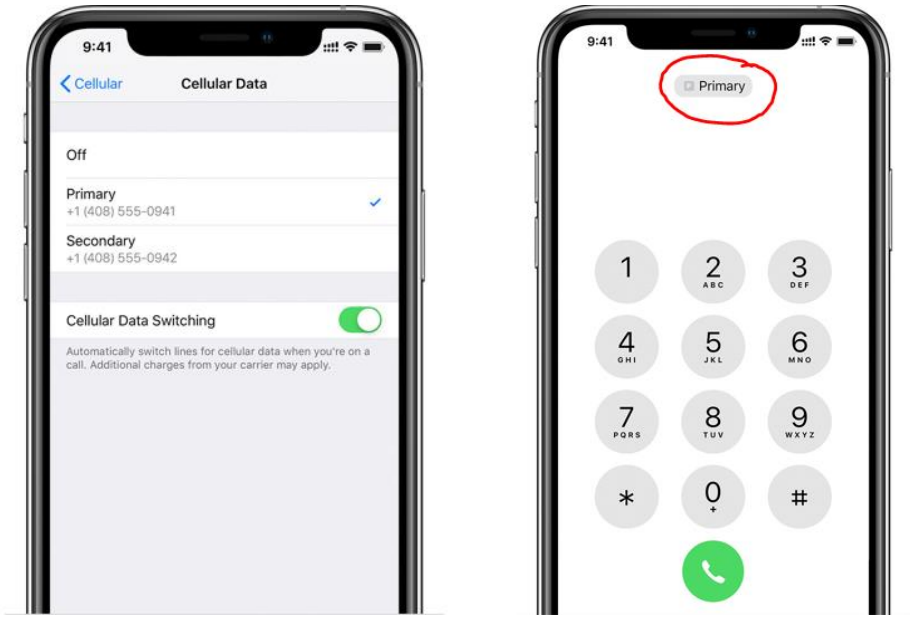
Use Secondary as your default line: If you select this option, Secondary will be used for voice, SMS, Data, iMessage, and FaceTime. Primary will be available just for voice and SMS.

Use Secondary for cellular data only: You might want to select this option if you're traveling internationally and you want to keep Primary for voice, SMS, iMessage, and FaceTime. This will allow you to use Secondary for data.

Source: Apple.[73]

73 https://support.apple.com/en-us/HT209044.

Figure 2-23: eSIM in the iPhone – use primary and secondary line for calls and data



Source: Apple.[74]

The number of providers offering subscriptions which can be implemented via the eSIM in iPhones has been continuously growing (from 14 carriers in November 2018 to 48 providers in January 2019).[75] Until now, there are no innovative, eSIM-specific tariffs in place. Instead, providers just adapted there processes to allow their customers to make use of the eSIM for existing offers. This holds for the mobile operators as well as for specialised roaming providers such as GigSky and Truphone – their tariffs are the same irrespective of the kind of SIM card used.

Among the latest developments with regard to the introduction of eSIM is its integration into ***laptops***. This process is still ongoing and could have a major impact on the consumer segment. One of the enablers of this development is Microsoft, which has created a whole Windows ecosystem for eSIM which involves a wide range of partners (see Figure 2-24).

74 https://support.apple.com/en-us/HT209044.
75 A list of providers offering tariffs for eSIM in iPhones is available at https://support.apple.com/en-us/HT209096.

Figure 2-24: eSIM-based solutions by Microsoft (Mobile Plans app)

Source: Treves (2018).[76]

At the end of 2016, Microsoft had announced that eSIM, in cooperation with Qualcomm, would soon be introduced for Windows 10.[77]

In early 2017, Microsoft signed a partnership with Gemalto for Subscription Management.[78]

In mid-2017, more details about the plans were published referring to the next generation of Windows 10 hardware and the introduction of the "Always Connected PC". At this time, discussions with the network operators were still ongoing. [79]

In 2018, the "Mobile Plans app" in Windows 10 was presented.[80] It was designed to set up and manage a cellular data plan with a supported mobile operator.

A precondition for the use of Mobile Plan app in Windows 10 are eSIM-equipped laptops, which are not yet widespread. Microsoft has started to produce its own

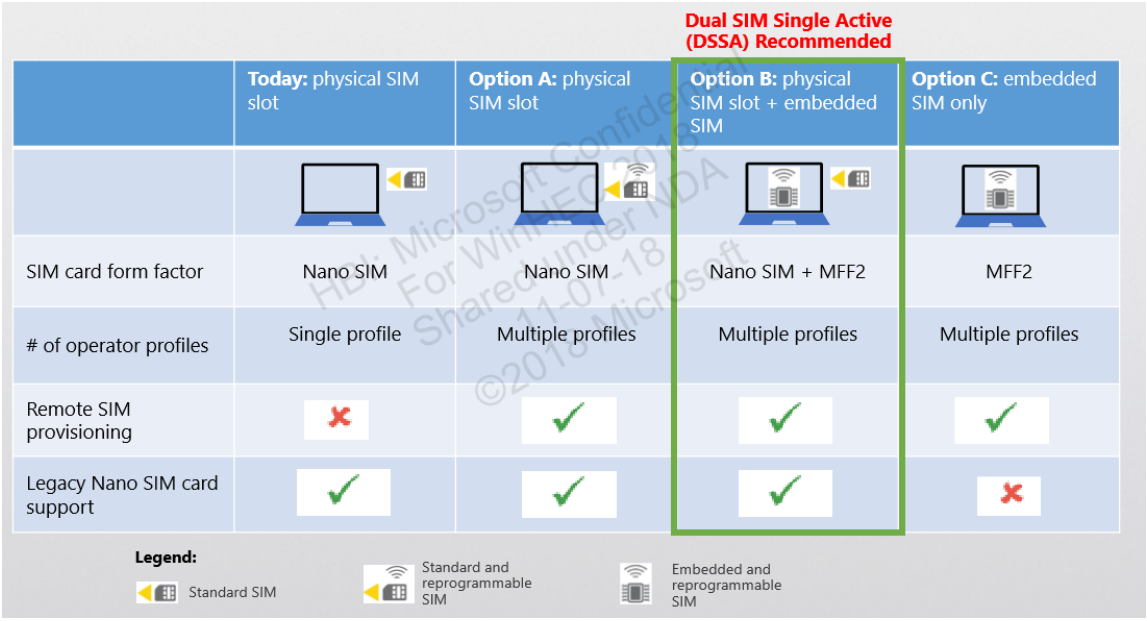
76 See Treves, M. (2018): Building and leveraging the next generation of Connected Devices, https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE2IO4V, slide 26.
77 See https://news.microsoft.com/2016/12/07/microsoft-empowers-new-development-opportunities-in-mixed-reality-gaming-and-cellular-pcs/#sm.0013qu9yy15kodewwtq119snr159i.
78 See Gemalto (2017): Gemalto and Microsoft join forces to provide seamless connectivity for Windows 10 devices, press release, 21 February 2017, http://www.gemalto.com/press/Pages/Gemalto-and-Microsoft-join-forces-to-provide-seamless-connectivity-for-Windows-10-devices.aspx.
79 See Sauter, M.; Sebayang, A. (2017): Windows 10 on ARM soll Intels x86-Ultrabooks übertreffen, 1 June 2017, https://www.golem.de/news/always-connected-pc-windows-10-on-arm-soll-intels-x86-ultrabooks-uebertreffen-1705-128108.html.
80 See e.g. https://uk.pcmag.com/news-analysis/94262/microsoft-store-to-offer-lte-data-plans-for-esim-pcs.

eSIM-equipped PCs (Surface Pro). Other eSIM-equipped laptops are available from leading computer manufacturers, including Lenovo ThinkPadX1 Carbon, HP Elite Book 1040 and Asus NovaGo.

Moreover, the number of carriers that support Microsoft eSIM is still limited. In June 2018, KDDI (Japan), Swisscom (Switzerland), and Tele2 (Sweden) were the only operators, in November 2018 Gigsky and Ubigi joined this group.[81]

For Microsoft, eSIM is a "tool to enable LTE connectivity seamlessly for both consumer and commercial" with different options for implementation, i.e. as dual SIM, physical SIM or embedded SIM (see Figure 2-25).

Figure 2-25: Microsoft: Different SIM options



Source: Treves (2018).[82]

As with the eSIM in the iPhone the number of activated eSIM in laptops is not known and can be assumed to be very low.

2.2.2.3 Attitudes of MNOs towards eSIM

As discussed in the previous sections, there is a strong interest from certain equipment manufacturers in eSIM. eSIM also provides new opportunities for specialist global

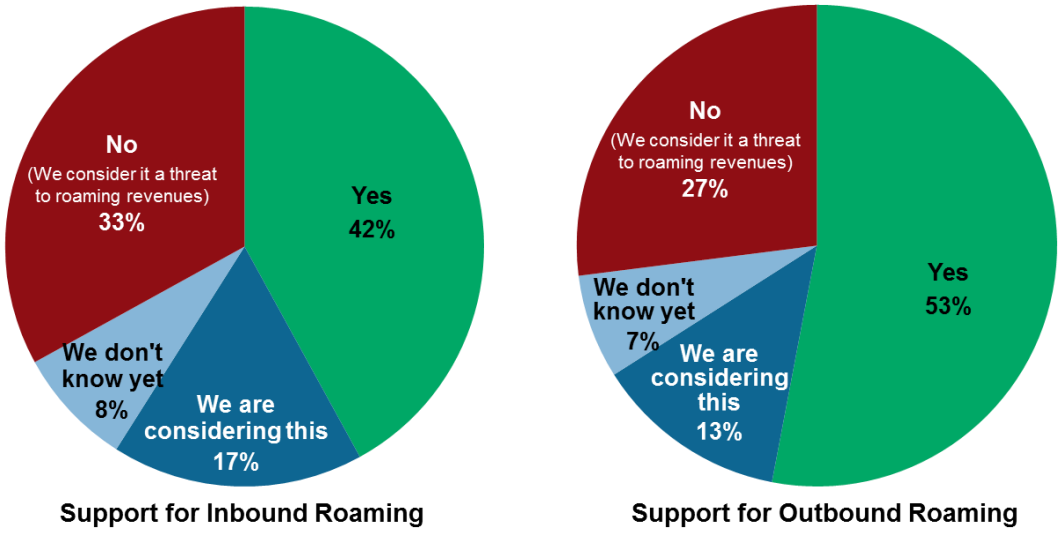
81 See Microsoft, https://www.microsoft.com/en-us/windows/lte-connectivity-mobile-plans-app.
82 See Treves, M. (2018): Building and leveraging the next generation of Connected Devices, https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE2IO4V, slide 27.

connectivity providers – providers and use cases are further discussed in section 2.3.1. However, the interests of MNOs are more mixed.

On the one hand, MNO are evaluating the potential of eSIM for their business models and are aiming to exploit opportunities related to M2M and IoT.

A survey by ROCCO of 107 mobile operators, conducted in October/November 2017, concluded that MNOs are interested in implementing inbound and outbound roaming use cases for eSIM (see Figure 2-26), [83] although, at this time the majority of MNOs were not far advanced with regards to evaluating strategic options and impacts on their business models.[84]

Figure 2-26: MNOs plans to support inbound and outbound roaming



Source: ROCCO (2018).[85]

On the other hand, about one third of the MNOs consider eSIM-enabled roaming scenarios as a threat to their roaming revenues (see Figure 2-26). MNOs have been reluctant to promote eSIM for consumer use following its introduction into this segment by manufacturers (particularly Apple).

83 See also ROCCO (2018): eSIM for the Roaming Consumer - Strategy Report 2018, http://marketing.uros.com/ROCCO%20Roaming%20Consumer%20eSIM%20Strategy%20Report%202018.pdf, page 22.

84 See also ROCCO (2018): eSIM for the Roaming Consumer - Strategy Report 2018, http://marketing.uros.com/ROCCO%20Roaming%20Consumer%20eSIM%20Strategy%20Report%202018.pdf, page 26.

85 See ROCCO (2018): eSIM for the Roaming Consumer - Strategy Report 2018, http://marketing.uros.com/ROCCO%20Roaming%20Consumer%20eSIM%20Strategy%20Report%202018.pdf, page 22.

There are several indications that MNOs are still not promoting the eSIM:

- MNOs were mainly involved in the GSMA specification which also reflects some restrictions with regard to a flexible switching process, e.g. only one profile can be activated at the same time.
- The current activation process seems to be too complex to provide ease of use and to be convenient for addressing the mass market.
- MNOs do not encourage their customers to activate the eSIM in the respective devices.[86]
- Finally, some competitive issues have arisen even at this early stage of eSIM market development:
    - In the US, the Department of Justice has opened a probe into alleged coordination by AT&T, Verizon and the GSMA which were alleged to have slowed down the adoption of eSIM standards. It is rumoured that the investigation had been initiated by Apple.[87]
    - In Singapore, a public consultation was initiated in Summer 2018 to address the proposal of extending Singapore's current "no SIM-lock" policy to eSIM-enabled devices. It was proposed to forbid operators and MVNOs from locking devices imported into or sold in Singapore. Other proposals include a "light touch" licensing approach where device manufacturers, importers and sellers are only required to register eSIM devices with the IMDA and to obtain a telecoms dealer's (class) license.[88]

Thus, the impact of eSIM on competition in the roaming and global connectivity segment – especially that related to consumers, may in part depend on the degree to which the technology is able to fulfil its potential in facilitating switching while travelling. Different players in the value chain including mobile operators and equipment manufacturers may have differing and conflicting interests in steering customers to particular suppliers, which could be the source of potential competition concerns.

86 For example, in its FaQ for consumers, Deutsche Telekom points out that the advantage of the eSIM is the possibility to use two different contracts on a smartphone. Regarding the use of the iPhone with a single contract, Telekom recommends its customers to prefer a physical SIM. It explains to them that the physical SIM-card can be simply inserted into another device, when the battery is empty (and no charger at hand) and claims that an eSIM profile is not easily transferred from one device to another, See FaQ https://www.telekom.de/hilfe/geraete-zubehoer/handy-smartphone-tablet/apple/iphone/iphone-xs-iphone-xs-max/vorteile-esim-beim-iphone?samChecked=true.

87 See e.g. Spanjaard, T. (2018): Consumer eSIm not likely to happen soon!, 1 May 2018, in: Smart Insights, https://www.smartinsights.net/single-post/2018/05/07/Consumer-eSIM-not-likely-to-happen-soon.

88 See IMDA (2018): Consultation Paper issued by IMDA, 6 June 2018, https://www.imda.gov.sg/-/media/imda/files/inner/pcdg/consultations/consultation-paper/public-consultation-on-embedded-sim-technology/consultation-document-for-esim.pdf?la=en.

2.2.2.4 Future Outlook

The eSIM is still in a very early stage in development, especially in the consumer segment. The future diffusion of eSIM is difficult to predict, given the large number of influencing factors.

2.2.2.4.1 Overview eSIM forecasts

There are a limited number of studies about the future of eSIM. They refer to the global market and make use of different indicators to predict eSIM developments (see Table 2-3).

In our survey among operators and in the interviews conducted for this study we also asked stakeholders about their future expectations. These varied widely.

Table 2-3: Overview of forecasts for the worldwide eSIM development

Published by	Time period of forecast	Main findings
Markets and Markets (2018)	2018 - 2023	• The eSIM market is estimated to grow from USD 253.8 Million in 2018 to USD 978.3 Million by 2023, at a CAGR of 31.0% between 2018 and 2023. • The overall eSIM market was valued at USD 179.6 Million in 2017. • The overall eSIM market is estimated to register a shipment of 287.7 million units in 2016 and is likely to witness a shipment of 1,168.8 million units by 2023, at a CAGR of 32.4% between 2018 and 2023.
BIS Research (2018)	2018-2028	• The global eSIM market generated $214.7 million in 2018 and is estimated to grow at a CAGR of 40.70% during the forecast period 2018-2028. • Europe dominated the global eSIM market in 2017, followed by North America. • The M2M/IoT device type accounted for the largest market in the global eSIM market in 2017, both in terms of value and volume. This is majorly due to the wide penetration of eSIMs in the automobiles for M2M connectivity.
Ovum (2018)	2017 - 2022	• Ovum expects the eSIM market to grow from 4.4 million to 612 million device unit sales between 2017 and 2022. • Smartphones will make up more than 90% of all eSIM sales by 2022, with plenty of room for further growth as only 28% of smartphones sold in 2022 will use eSIM.
Abi Research (2018)	2022	• The eSIM smartphone market is set to reach 420 million units annually by 2022. Due to Apple's decision to incorporate the technology into its iPhone XR, XS and XS Max devices eSIM market growth will accelerate.
IHS (2017)	2016 - 2021	• The embedded eSIM market is projected to increase nearly nine-fold, from a relatively small base of 108.9 million shipments in 2016 to 986 million shipments in 2021 • The proportional importance of the removable SIM will decline over time, from 5.4 billion shipments (98.0% of the total) in 2016 to 5.1 billion (83.9% of the total) in 2021.

Sources: Research and Markets[89], BIS[90], Ovum[91], Abi Research[92], IHS.[93]

89 Markets and Markets (2018): eSIM Market by Application (Connected Cars, Laptops, M2M, Smartphones, Tablets, Wearables), Vertical (Automotive, Consumer Electronics, Energy & Utilities, Manufacturing, Retail, Transportation & Logistics), and Geography - Global Forecast to 2023, https://www.marketsandmarkets.com/Market-Reports/esim-market-69178757.html.

90 See BIS Research (2018): Global embedded SIM (eSIM) Market - Focus on Device (M2M/IoT, Wearables, and Smartphones), End-user Industry (Automotive and Consumer Electronics), and Region - Analysis and Forecast, 2018-2028, https://bisresearch.com/industry-report/embedded-sim-market.html

91 See Ovum (2018): eSIM Device Sales Forecast: Smartphones, Tablets, and Wearables, 2017–22, https://ovum.informa.com/resources/product-content/esim-device-sales-forecast-smartphones-tablets-and-wearables-201722-ces004-000052.

92 See Abi Research (2018): eSIM Smartphone Shipments to Exceed 400 Million by 2022, as Apple's New Smartphones Accelerate the Market, https://www.abiresearch.com/press/esim-smartphone-shipments-exceed-400-million-2022-apples-new-smartphones-accelerate-market/.

93 See IHS (2017): eSIM Market Projected to Increase Nearly Nine-Fold, to Almost One Billion Shipments, https://technology.ihs.com/591806/esim-market-projected-to-increase-nearly-nine-fold-to-almost-one-billion-shipments.

2.2.2.4.2 WIK estimate on future development of eSIM

For this study, we estimated the current status of eSIM deployment in the European market, divided between the M2M and consumer segments.

Based on the studies listed under Section 2.2.2.4.1 and on the expert interviews conducted for this study, we can derive some stable trends:

- Market experts agree that eSIM will gain importance in both consumer products and enterprise and IoT devices.
- Starting from a low number of eSIM devices today, they expect a significant growth of various eSIM equipped devices, ranging from smartphones to wearables (i.e., smartwatches, smartglasses, etc.), smart speakers, smart TVs, PCs and connected cars.
- Within the M2M segment, connected cars will continue to be among the most important applications for eSIM.
- In the consumer segment, enterprise customers are seen as the early adopters. eSIM is likely to prove particularly relevant for multinational companies requiring flexible solutions for their employees and facilities cross-border.
- Current product launches, the strategic approaches of the relevant players as well as customer behaviour suggest that eSIM will not fully replace traditional SIM cards in the long-term.

However, the extent to which eSIM will penetrate the market depends on several factors which are highly uncertain:

- Availability of eSIM-equipped devices depends on the strategies of leading manufacturers:
    - After the launch of eSIM-equipped smartphones by Apple in 2018, the future growth of eSIM in consumer devices will depend on the product launch of leading smartphone manufacturers such as Samsung and Huawei, as well as Apple’s future strategy in this area.
    - While current eSIM-equipped smartphones are dual SIM and enable the user to ignore eSIM it is uncertain, if and when eSIM-only smartphones will be launched.
    - The growth of eSIM in PC/laptops driven by Microsoft is very likely, but the extent depends on the launch of the related eSIM hardware. As this is the latest development with high relevance for consumer eSIM neither data about the current status is available nor any expectations with regard to the future.

  - It is difficult to forecast, which share of M2M devices will be connected via mobile networks (as opposed to fixed networks).
  - It is unclear, which role different SIM card formats will play in future (e.g. M2M SIM cards, that are soldered, but not reprogrammable).
- Activation of eSIM depends on the product strategies of mobile connectivity providers and on customer acceptance:
  - For major take-up a decrease in complexity of existing solutions will be required, e.g. with regard to the activation process for the eSIM.
  - An increase in take-up can be expected as soon as eSIM can be exploited to offer innovative tariffs (e.g. multi-device-tariffs).
  - If swift switching processes are available, customers will have greater insights into the advantages of eSIM.
  - Overall, many issues related to contractual policies under eSIM are still open. For example, it is not clear to what extent mobile connectivity providers will adapt existing contractual policies for eSIM based subscriptions.

For the distinction between M2M and consumer, we define all applications that involve a very limited role of a human as M2M. From this perspective, activation or monitoring of a M2M application or M2M device by a human via a technical device such as a smartphone or tablet is regarded as M2M (e.g. smart home) while the consumer segment includes smartphones, wearables, tablets, laptops and other/new devices.

Our estimate is based on public data sources, e.g. from GSMA, EU and OECD as well as on company information (e.g. Apple) and is crosschecked with results from studies of other market researchers and analysts (e.g. Markets an Markets, Ovum, IHS, see Table 2-3).

Moreover, we provide an estimate for the penetration of eSIM in different devices until 2030.

A key assumption is that all manufacturers and providers that have been developing and promoting the eSIM in the context of GSMA will persist with this technology in the future and will launch related products and services. This assumption seems realistic, as all these players have made significant investments in eSIM technology. Moreover, we expect improvements in the customer journey and usability of eSIM that will increase uptake.

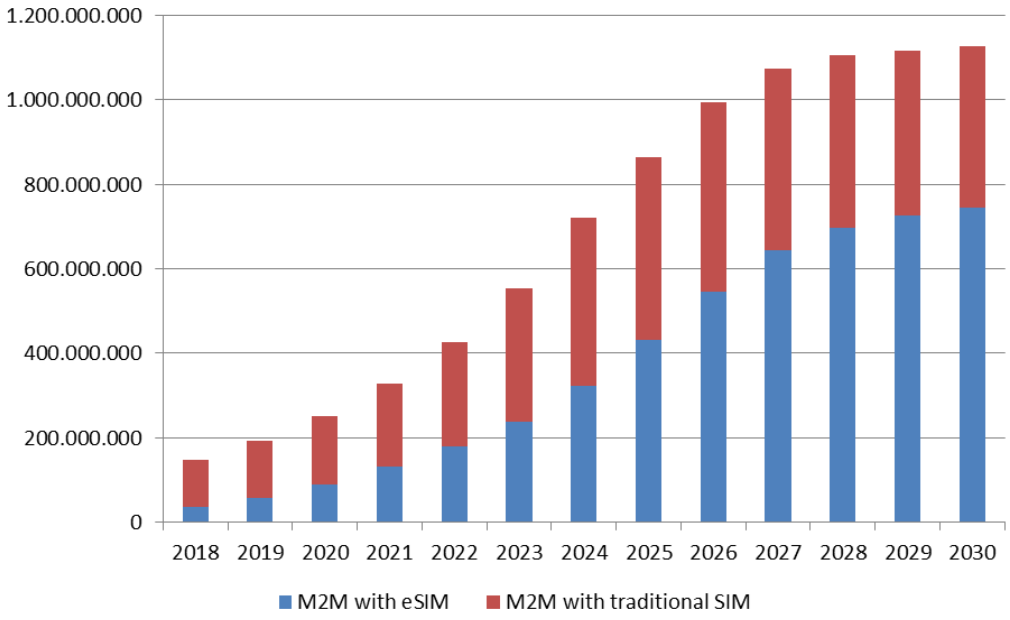
However, our estimate is conservative as it does not assume that eSIM will fully replace traditional SIM within 10 years. Nevertheless, at least for some product categories like e.g. laptops, this could also be regarded as a potential scenario.

For the ***M2M segment***, we take the following approach:

- For the current status, we rely on the data provided by OECD on total number of SIM cards.
- We assume that 25% of all M2M SIM are currently eSIM. Based on other studies and expert opinions, it seems realistic to assume that this share might grow until 2030 to about 70% (see Figure 2-27).
- As SIM is a key element of an M2M solution, all eSIM in M2M can be assumed to be in use/activated for the whole period of time (see Figure 2-30).

It should be noted that in the overall M2M market and for IoT, mobile connectivity is not always required for implementation. WLAN, narrowband IoT and other technologies also play a significant role. M2M applications based on SIM are only one option of many for connecting devices.

Figure 2-27: Total number of eSIM and traditional SIM in M2M (2018-2030) in EU28



Source: WIK-Consult.

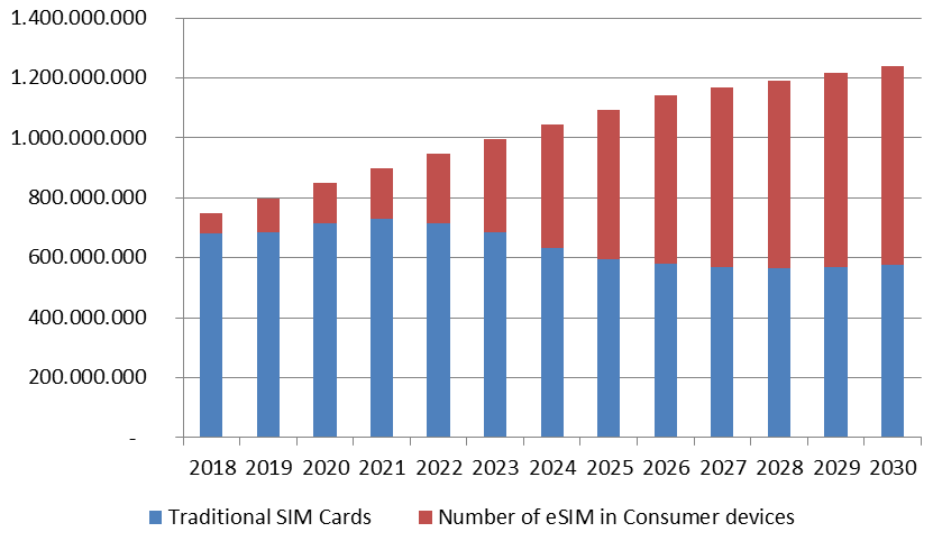
For the forecast on eSIM in the ***consumer segment,*** our approach is as follows:

- We distinguish three product categories: smartphones, wearables and “other devices” (including tablets and laptops).
- First, we identify the total number of SIM-equipped devices in Europe today based on sales numbers of leading suppliers provided in annual reports. Here, several assumptions have to be made. As Apple only provides global sales

numbers, we assume that 25% of all products are sold in Europe – this equals Europe's share in Apple's revenues. For Google Pixel we assume a share of 7% for Europe.

- Then, we apply a share for eSIM in total SIM. This share is assumed to be lower than 10% for smartphones, tablets and laptops, while, wearables with SIM are assumed to be almost 100% eSIM-enabled.
- Next, we derive our forecast based on the stable trends outlined above:
- Due to a growing number of SIM cards per subscriber we expect about 1,2 billion SIM cards at the end of the period (2030), i.e. about 2,6 SIM cards per subscriber (compared to 1,5 SIM cards in 2018).At the beginning, the growth in the number of SIM cards to serve the growing number of devices still relies mainly on traditional SIM, but eSIM will slowly gain larger shares.
- Based on this development, the share of traditional SIM in all SIM cards implemented in consumer devices will decrease from about 90% in 2018 to about 50% in 2030. In other words, half of all SIM-equipped consumer devices will contain an eSIM[94] by the end of the forecast period (see Figure 2-28).

Figure 2-28: Total number of eSIM and traditional SIM in the consumer segment (2018-2030) in EU28



Source: WIK-Consult.

This development can be expected based on the growth of eSIM in different device categories:

94 Especially in the early phase, devices with an eSIM may also contain a traditional SIM.

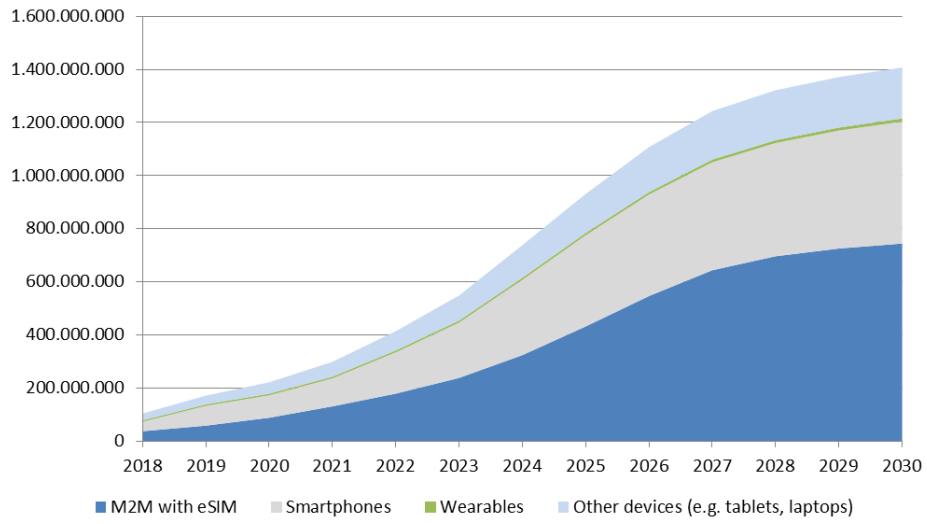
We expect that other ***smartphone*** manufacturers such as Samsung and Huawei will launch eSIM equipped smartphones in 2019 and others will follow in the coming years with the result that in 2030 about 460 million smartphones with eSIM functionality will be available in Europe (based on the above mentioned assumptions that all relevant manufacturers will implement eSIM step-by-step). Apple's share in eSIM smartphones will decrease from 98% in 2018 to 22% in 2030. These numbers are highly uncertain, as manufacturers product strategies are difficult to predict.

We assume that dual SIM-smartphone will be the dominant model in the coming few years. Therefore, the share of activated eSIM in smartphones is still low and will grow at a low rate (which is, however, highly dependent on the ease of use and customer acceptance).

Wearables can be expected to represent a niche market that could account for about 2% of all eSIM equipped consumer devices in 2030.

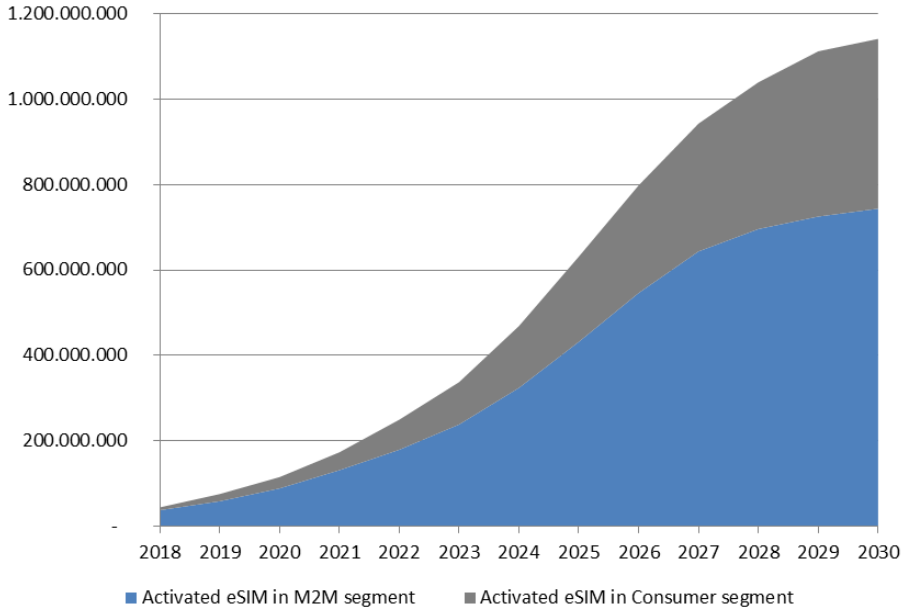
Other eSIM equipped devices in the form of tablets, laptops (and some new devices not yet known) will also increase, but in 2030 are still not expected to constitute more than 30% of all eSIM-equipped consumer devices. However, it should be noted that the integration of eSIM into laptops is at a very early stage today and is difficult to predict based on current trends. It is also possible that due to Microsoft's eSIM ecosystem approach, a wide range of manufacturers will integrate eSIM. Thus an eSIM penetration in laptops approaching 100% cannot be excluded. Here, the low cost of eSIM compared to the total cost of a laptop should be taken into consideration and distinguishes this segment from smartphones where eSIM functionality might not be provided in low-cost models.

Figure 2-29: Total number of devices with eSIM in EU (2018-2030)



Source: WIK-Consult.

Figure 2-30: Total number of devices with activated eSIM in EU, by category (2018-2030)



Source: WIK-Consult.

2.2.2.5 Implications of eSIM for competition in roaming and global connectivity

By facilitating the expansion of new global markets for connected things and connectivity for personal devices, including laptops and tablets, eSIM has opened the door for alternative providers specialized in global connectivity to win share and directly market their services to equipment manufacturers and verticals. At the same time, device manufacturers/OEMs could play an important role in influencing competitive entry in these markets through preselection of MNOs/service providers marketed to the end user. In the past, this happened with the Apple SIM in iPads.

Due to the potential for over-the-air provisioning, eSIM also facilitates switching in IoT/M2M markets. For example, as regards connectivity for connected cars, there is a significant benefit for eSIM solutions over fixed SIM solution for OEMs, which is the ability to switch providers at their convenience and even migrate their whole fleet of cars long after they have been sold. The eSIM potentially also offers alternative options for customers who might otherwise be bound to a purchase data plans from a specific MNO after the original flatrate typically included in connected car services options has expired.[95] In sum, the potential for and implications for eSIM on competition in global connectivity/roaming for IoT/M2M could be significant.

95 Virtually all OEMs which offer built-in SIM cards for their connected car services also offer an initial flatrate including all roaming for their cars when purchased new. Typically, the flatrate expires after 36

eSIM could also facilitate increased choice in roaming connectivity for mobile handsets, by providing improved opportunities for consumers to switch to alternative providers for roaming services, compared with existing options such as “plastic roaming” (the swapping out of physical SIM cards). For eSIM-enabled iPhones, several providers have business cases that are highly relevant for consumer roaming, including Truphone, GigSky and Uros (see case studies for these providers in Section 2.3.1). However, there are some important limitations which may impact competition in this segment.

Firstly, the market for mobile roaming on handsets is more mature, which means that more effort would be needed for enable a breakthrough in market share by alternative providers. Moreover, eSIM in smartphones is thus far limited to premium models only. Users of these models can be assumed to be less price sensitive than others. Therefore, they might tend to keep stable relationships with their existing connectivity provider and may have less incentive to switch provider or to use alternative roaming offers.

Secondly and importantly, consumers today require access not only to data, but also to voice and SMS when roaming, and prefer to remain contactable on their primary phone number. Users would thus need to have simultaneous access to two profiles – one for voice and SMS (via their primary ‘home’ communication provider), and the other for data and potentially other communication services (from an alternative provider) – if they are to benefit fully from competition when roaming.[96]

With the introduction of eSIM, this may change as handsets equipped with eSIM today are based on a dual-SIM smartphone with one traditional SIM and one programmable eSIM. Here, the alternative profile downloaded to the eSIM can be used for data and OTT services, and might possibly also be usable for placing calls and sending SMS messages. The new profile is downloaded and/or activated in the eSIM by means of an app (with the identity established by for instance scanning a printed QR code). This process does not disrupt arrangements with the home operator – that subscription continues to be supported by the traditional SIM, and is typically used to receive calls and SMS messages sent to the consumer’s usual phone number in the home country.

months. (see Tenbrock, Sebastian, & René Arnold. 2016. Die Bedeutung von Telekommunikation in intelligent vernetzten PKW - WIK Diskussionsbeitrag Nr. 413. Bad Honnef: WIK).

96 Some consumers already use a dual SIM phone, with two traditional (removable) SIM cards, as a means of avoiding roaming charges without having to carry a second mobile device and without losing calls to their usual number in the home country. This approach enables the consumer to have a new identity associated with the visited country, but also to receive calls on the consumer’s phone number in the home country. Dual-SIM phones, however, are not very popular in Europe (possibly because regulation of roaming in the EU/EEA since 2007 meant that the economic advantage that they offer is less than in many other parts of the world). According to the DeviceAtlas, only in India, Indonesia, Egypt and Ukraine are dual-SIM phones more popular than single SIM phones. The lowest popularity was registered in the UK (5,94% of all smartphones in the country). However, the iPhone XS succeeded in becoming the most popular dual-SIM smartphone in Denmark, France, the Netherlands, Sweden, the UK and some countries outside Europe. See Device Atlas (2019): Dual SIM smartphone usage – 2019, 9 April 2019, https://deviceatlas.com/blog/dual-sim-smartphone-usage.

The service provided via the eSIM offers an *additional* service to the consumer in the visited country.

However, this benefit may be disappear as removable SIM cards are phased out over the coming years, because under current GSMA standards, an eSIM can support only one active profile at a time. For an eSIM-only smartphone to support a dual-SIM usage model, it would be necessary either for the smartphone to have two eSIMs, or else to support some possible future eSIM standard that had been extended to permit more than one profile to be active at a time in a single eSIM. As noted in Section 2.2.2.3, it is unclear to what extent the restriction in the current standard is motivated by underlying technical factors, versus being a possibly anticompetitive practice that could perhaps be addressed; consequently, it is too soon to say whether a suitable revision to the current GSMA standard is likely to be forthcoming.

Some current implementations are slightly different from the GSMA specification, mainly in terms of the customer activation process. At first glance, these customer activation deviations do not appear to involve significant risks for a future change of provider, as the processes with regard to subscription management and any interfaces are more or less standardised. However, it cannot be excluded that implementation scenarios that deviate from current or future GSMA specifications might either harm or benefit provider switching from the consumer perspective in practice.

In any event, it should be noted developments in the specification and implementation of eSIM could significantly impact the potential for competition in roaming services over consumer handsets.

Finally, it should be noted that any limitations in competition affecting consumer handsets, could also influence competitive dynamics in neighbouring markets such as the provision of connectivity for other connected personal devices such as watches, tablets and laptops, especially if as expected, multi-device-contracts become commonplace. The larger the number of connected devices under a single contract, the more burdensome the user is likely to perceive any switching of providers, because multiple devices have to be switched at roughly the same time. This conclusion is consistent with lessons learned from the effects of bundling on the churn reduction (e.g. dual play and triple play services).[97]

97 See e.g. Grzybowski, Lukasz; Liang, Julienne; Zulehner, Christine (2017): Bundling, consumer retention and entry: evidence from fixed broadband market. 14th International Telecommunications Society (ITS) Asia-Pacific Regional Conference: "Mapping ICT into Transformation for the Next Information Society", Kyoto, Japan, 24-27June, 2017, https://www.econstor.eu/bitstream/10419/168483/1/Grzybowski-Liangy-Zulehner.pdf or OECD (2015): Triple and Quadruple Play Bundles of Communication Services, OECD Science, Technology and Industry Policy Papers, No. 23, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/5js04dp2q1jc-en.pdf?expires=1560420143&id=id&accname=guest&checksum=188D1E5053B5B193923E1101A98E04E2.

There can also be technical limitations which require multiple devices to be served by the same provider. The Apple Watch, for example, cannot be (fully) used without an iPhone and also requires the use of the same mobile carrier as the iPhone. As Apple explains: *"Your iPhone and Apple Watch must use the same carrier. If you change carriers on your iPhone, you need to remove the previous service plan on your Apple Watch and sign up for a new plan."* If the user has a dual SIM/eSIM iPhone and makes use of several tariffs, these tariffs can also be used for the Apple Watch (up to 5 different tariffs can be stored); however, only one of these tariffs can be used at the same time. This means that the user cannot be reached via different mobile phone numbers on his or her Apple Watch.[98]

To conclude, in 2016, a study for the European Commission in the context of the review of the wholesale roaming market stated that the lack of availability of eSIMs and the lack of operators supporting the eSIM were the main factors limiting the potential of eSIM as a viable substitute for roaming with a home mobile network operator. At this time, there was a high uncertainty regarding the strategy of the relevant market players.[99]

Both bottlenecks are about to be overcome, as global players like Apple and Microsoft have integrated the eSIM in their products and providers have started to develop related offers. However, there are other factors which could limit the potential of eSIM to facilitate competition in roaming and global connectivity markets, especially in the handset and consumer device segments. Some of these factors could in theory be addressed by commercial practice or regulatory action, while others such as market maturity in connectivity for consumer handsets may prove harder for new entrants to overcome.

2.2.2.6 Permanent Roaming

The Roaming Regulation as amended by the Telecom Single Market Regulation, allows MNOs to set limits on the usage of EU roaming services to prevent their subscribers from "abusive" or "anomalous" roaming behaviour ("fair-use-policy"). In this context, MNOs can monitor their customers' roaming use over a four- month period. A surcharge may be charged[100] if the customer has spent more time abroad than at home and if roaming usage has exceeded the domestic usage within this period. MNOs may also include conditions in their reference offer designed to "prevent permanent roaming or

98 See for more details Apple Support: Use Dual SIM with Apple Watch Series 4, https://support.apple.com/en-gb/HT209043 .

99 See e.g. European Commission (2016): COMMISSION STAFF WORKING DOCUMENT Accompanying the document "Report from the Commission to the European Parliament and the Council on the review of the wholesale roaming market" {COM(2016) 398 final} Brussels, 15.6.2016 SWD(2016) 200 final https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2016:0200:FIN:EN:PDF, page 38-39.

100 Caps in 2019: 3,2 cents per minute of voice call made, 1 cent per SMS, and €4,5 per GB of data

anomalous or abusive use of wholesale roaming access for purposes other than the provision of regulated roaming services to roaming providers' customers while they are periodically travelling within the EU".[101] According to BEREC, permanent roaming currently does not play a major role.[102] It reports little evidence of abusive use, or of major actions from MNOs to enforce fair use.

However, permanent roaming is likely to play an increasingly important role in the context of connected cars and certain other IoT applications. The BEREC Guidelines concerning the roaming Regulation[103] note that "it is common for devices for M2M communications to be used on a permanent roaming basis", and therefore "it may make sense to assess M2M communications on a case-by-case basis".

However, service providers specialising in the provision of connectivity for connected IoT and cars observe problems in the application of this principle.

One concern raised by MVNOs is that the distinction between M2M vs personal communications may not always be clear. Roaming on a consumer handset is clearly personal communications and telemetry is clearly M2M. Infotainment in a car where the customer is paying seems to be similar to infotainment on a handset. However, they note that B2B infotainment, where the consumer does not buy the service – is a grey area. Some operators/regulators decide that it involves human intervention while others see it as an extension of M2M service. In general, they note that the approaches across different countries and operators differ, resulting in a fragmented regulatory landscape.

Beyond the regulatory challenges, there can also be challenges with acceptance of non-national IMSIs. In some cases, the reticence can come from the customer. MVNO/As also report that some mobile operators have taken steps to block or limit permanent roaming to avoid the risk of domestic customers being targeted by multi-national connectivity suppliers. There is also a new trend from some local operators to offer a higher cost product for permanent roaming for IoT – based on a fixed cost for accessing network, together with an SLA agreement.

The lack of a consistent approach to permanent roaming for IoT has also been cited as a barrier for MVNO/As to offer solutions to manufacturers requiring connectivity for devices which are mobile (such as trackers) or distributed across multiple countries, such as smart metres.

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101 Article 7 of the 2015 TSM Regulation.

102 See BEREC Opinion on the functioning of the roaming market, as input to the Commission's evaluation BoR(19)101, https://berec.europa.eu/eng/document_register/subject_matter/berec/opinions/8595-berec-opinion-on-the-functioning-of-the-roaming-market-as-input-to-ec-evaluation. Also see European Parliament (2018): Roaming – One year after implementation, Policy Department for Economic, Scientific and Quality of Life Policies Directorate – General for Internal Policies, In-Depth Analysis requested by the ITRE committee, written by Blackman, C. and Forge, S., November 2018, www.europarl.europa.eu/RegData/etudes/IDAN/2018/626090/IPOL_IDA(2018)626090_EN.pdf, page 15.

103 Point 191 https://berec.europa.eu/eng/document_register/subject_matter/berec/download/0/7005-berec-guidelines-on-regulation-eu-no-531_0.pdf.

The proliferation of eSIM may bring this issue into added focus as eSIM is likely to support the expansion of connected things across the EU, which may potentially entail permanent roaming. At the same time, by facilitating the use by consumers of multiple mobile profiles each with different identifiers, eSIM could make it more difficult for MNOs in visited countries to track whether "roaming" consumers are genuinely visiting for a short period, or are permanently roaming.

In general, in order to support the expansion of IoT in Europe as well as providing clarity on circumstances where permanent roaming can be denied including for consumer use, there seems to be a case for more explicit rules or guidelines on permanent roaming, and the use of non-national IMSIs, and for guidance on how M2M should be distinguished from personal communications,[104].

2.2.3 5G and network slicing

At one level, one might suppose that 5G is simply another mobile network technology, and that the shift will have little impact on international mobile roaming. There are scenarios, however, where the impact of 5G might be considerable.

2.2.3.1 5G as a substitute or complement for conventional retail roaming services

In Section 2.1.1 and elsewhere, we discuss the use of WiFi as a substitute for roaming. The use of WiFi today in hotels and transportation hubs probably represents the largest form of substitution in use in the EU today. In that section, we further explore the possibility that 5G, in conjunction with network "slices", might substitute for WiFi to a substantial degree in the future.

If it were to happen, this substitution would make little difference to the user; however, its implications for roaming are substantial, in that a substantial volume of traffic that today represents bypass traffic carried ultimately over the fixed network might then be carried by commercial mobile networks in both domestic and in roaming environments.

Many factors are likely to play into the decisions that consumers will ultimately make between WiFi and 5G, including:

- **Price:** a major driver of WiFi usage when roaming in the recent past has been avoidance of high and uncertain costs associated with data roaming.
- **Impact on data caps:** For high volume activities such as software downloads and video viewing, consumers may prefer to keep them on WiFi, especially when they have access to reliable free service. They may not wish to have high

104 Any such guidance may however fall beyond the scope of the Roaming Regulation and may thus need to be addressed separately

volume activities count against their usage caps, and may not want to risk arguments as to whether they have exceeded Fair Use Limits when roaming.

- **Speed, reliability, and convenience:** Once WiFi has been set up in a hotel or transportation hub, it generally works simply and reliably. There are claims that 5G can sometimes be faster than WiFi (see Section 2.1.1), but the degree to which consumers will prefer it in practice is not yet known.
- **Building penetration:** At 700 MHz, 5G should do well in terms of building penetration. In the pioneer 3.4 to 3.8 GHz band, however, some loss should be expected with building penetration. For millimetre waves at 26 GHz and above, buildings are largely opaque, including the windows.[105] This could perhaps be addressed by means of pico-cells inside of buildings. How this will play out in practice remains to be seen.

The migration to 5G potentially opens the door to the use of network "slices" with different capabilities in support of enhanced Mobile Broadband (eMBB) for consumers, as noted in Section 2.1.1. Beyond this, 5G slices are expected to play a key role in supporting the shift to the Internet of Things (IoT), where the "users" are devices, many of which will be associated with vertical industries. Just as people can roam, many IoT use cases (not all) entail roaming – consider, for example, connected cars.

A network "slice" provides a means by which an MNO can offer its customer the equivalent of a private mobile network by means of partitioning or slicing off capability from its existing network. Management of Quallity of Service (QoS) within the slice then becomes the responsibility of the customer, not that of the underlying network operator; for the arrangement to make commercial sense, however, the slice sold must be capable of providing the QoS that the customer needs.[106]

The ability to do network slicing depends on recently emerged technologies such as Software Defined Networks (SDN) and Network Function Virtualisation (NFV), both of which provide ways to de-couple network services somewhat from the underlying physical network.[107]

The provision of private mobile network facilities was already somewhat possible under 4G by means of the Access Point Name (APN), but 5G network slicing is expected to provide a much more comprehensive and robust solution.

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105 ITU-R (2015), Report ITU-R P.2346-0 (05/2015): Compilation of measurement data relating to building entry loss.

106 For any specific application, interaction with EU network neutrality rules needs to be considered.

107 See J. Scott Marcus and Gabor Molnar (2017), "Network Sharing and 5G in Europe: The Potential Benefits of Using SDN or NFV", presented at ITS Europe in Passau, at https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID3007398_code333755.pdf?abstractid=3007398&mirid=1.

2.2.3.2 The use of 5G as an alternative to wholesale roaming services

It is thought that some MNOs or MVNOs might choose to purchase a network slice in countries to which many of their outbound roamers travel. With proper steering (which is quite feasible today and largely but not perfectly effective), this would enable the MNO/MVNO that procures the slice to provide roaming services in that country without having to pay substantial wholesale roaming fees, and without incurring the cost of building an entire mobile network of its own. The same slice might if desired, and subject to any technical or contractual limitations, also be used to provide domestic mobile services or to meet the needs of vertical segments.

This would offer a distinctly different flavour than solutions such as the *Local Break-Out (LBO)* service that is described in Section 2.2.4. With LBO, the customer makes a business arrangement directly with a network operator in the Visited Country. With this sliced solution, the customer would instead have the sense of being served by an extension of the Home Network.

This solution could also avoid any need to transport roaming data from the Visited Country back to the Home Network (HN) (known as *home routing*) in order to provide a consistent look and feel to the user. With a sliced solution, the slice is effectively part of the Home Network.

How this will play out in practice remains to be seen. The economic desirability of this approach would appear to depend heavily on the relative cost of a slice in comparison to the wholesale payments for which it would substitute. An MVNO that operates as a Home Network might find it cost-effective, for example, to purchase slices for these purposes in countries in which it has large numbers of outbound roamers, but to continue to purchase conventional wholesale roaming services in countries in which it has only a small number of outbound roamers.

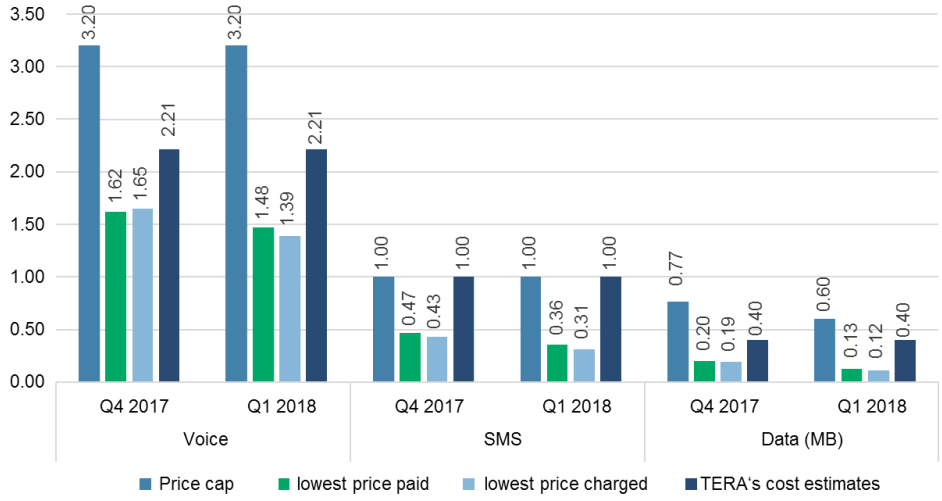
2.2.4 Wholesale capacity trading platforms

Although technologies such as eSIM might provide further opportunities for smaller operators and MVNOs to target segments of the international connectivity/roaming market, while 5G might provide the potential for such operators to have greater control over the quality of services that they offer, their ability of smaller operators and MVNOs to deliver attractive wholesale offers will continue depend on their ability to gain access to wholesale roaming or to settle multiple MVNO agreements via network slices (as in Section 2.2.3.2) or otherwise.

Under the current roaming regulation, this is addressed through wholesale roaming regulation. Stakeholders interviewed for this study indicated that regulated wholesale roaming rates were typically significantly above those offered through commercial

agreements. This is confirmed in BEREC reports, which show a consistent gap between the regulated wholesale price cap and the lowest price charged (see below).

Figure 2-31: Wholesale Prices for Roaming Services Q1 2017 and Q1 2018 Compared[108]



Source: BEREC (2018).

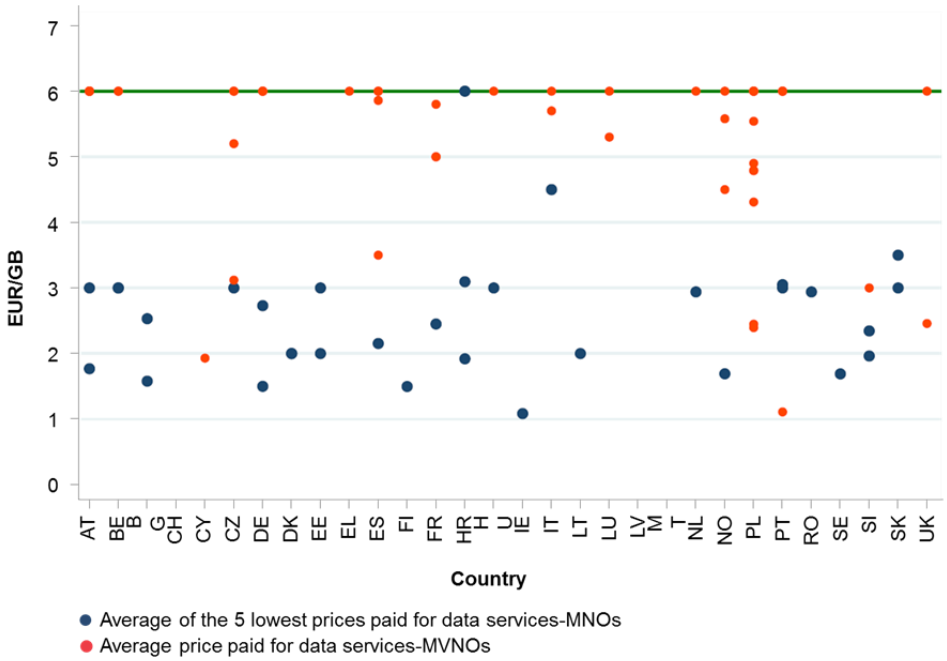
However, not all operators and service providers have been able to benefit equally from this dynamic.

Operators acting outside large groups (and thereby unable to secure on-net agreements) and those from countries with a high ratio of „roaming out" to „roaming in" volumes, found the greatest challenges in securing good deals in all markets.

Larger MVNOs that we interviewed indicated that there were reliant on regulated roaming rates for a significant amount of traffic for personal mobile roaming. These MVNOs were able to secure better deals for international connectivity/roaming in relation to IoT, but considered that there were still areas where regulated roaming rates were required for IoT. This feedback is supported by data published by the European Commission.[109]

108 BEREC 2018 - BoR (18) 160 International Roaming BEREC Benchmark Data Report October 2017 - March 2018.
109 COM(2018) 822 final.

Figure 2-32: Wholesale prices paid for data by MNOs (blue dots) and MVNOs (red dots)



Source: European Commission (2018).

One solution that has been proposed as a potential means to support competition in wholesale roaming is the potential development of trading platforms for mobile capacity. Such trading platforms would operate as a regulated exchange (similar to other commodity exchanges) and provide transparency in volumes and prices for mobile capacity (which could include domestic as well as international/roaming capacity), although the participants would remain anonymous.

Proponents of trading platforms argue that the main reason for market failures in wholesale roaming markets is that the system of bartering traffic distorts the pricing signal for roaming (in a similar manner to previous bartering of international capacity) because if traffic is perfectly balanced, the wholesale price is irrelevant. The bartering system also puts network operators whose customers are primarily roaming out at a disadvantage because they have little to offer in return. This is especially true for MVNOs that have no inbound traffic to trade.[110]

The theory behind such trading models is that by breaking the link between inbound and outbound capacity, a functioning market in capacity (for national and international

110 See for example Shortall Tony. (2010) 'Roaming in Europe and the United States' Utility Law Review 18(1), Infante Jorge, Vallejo Ivan 2012, Regulation of international roaming in the European Union—Lessons learned, Telecommunications Policy Volume 36, Issue 9; Dominguez, Javier, Competing for Partners: Strategic Games in International Wholesale Roaming (October 27, 2011).

roaming) could be created, which would provide an alternative to the capped regulated wholesale roaming rates that smaller mobile players rely on today. Proponents of electronic trading for telecom capacity observe that the current model for reaching roaming agreements is based on face to face "speed-dating" sessions conducted at annual events organised by the GSMA, and that a move away from this approach towards electronic trading would mirror developments in other commodity markets, in which trading evolved from bilateral "over-the-counter" deals to "open outcry" (in physical exchanges) towards electronic exchanges.

A challenge with treating mobile capacity as a commodity for anonymised trading is that, as was confirmed in interviews conducted for this study, it is unlikely to be supported by larger mobile groups, which already have a multi-national presence and are able to leverage their home market positions to develop advanced trading relationships with other carriers to support their roaming offers. Such a lack of interest from larger firms with their own assets or buyer power and established relationships may indeed have been behind the failure of earlier efforts at capacity trading (in the enterprise market) such as those pioneered by Enron.[111]

More recently, there have been renewed efforts to launch bandwidth trading platforms in the telecoms market, including some with a specific focus on mobile capacity, including roaming.

Tritex, one of the organisations planning to launch a trading platform is aiming to introduce trading on an incremental basis – starting with the digitisation of existing roaming relationships. Under this platform, agreements could be reached on a bilateral and/or reciprocal basis, and would not need to be anonymous. Tritex justifies the need for such a platform on the basis that existing arrangements based on "handshakes" and long lead times are unlikely to be sustainable with the increasing complexity in roaming products and expansion into IoT.[112]

Another initiative, the Cicada Exchange, would operate on the basis of anonymised trading of capacity, without any link between inbound and outbound traffic, similar to the trading of "commodities". The project is due to trial its capacity exchange in April 2019 with a number of MNOs and MVNOs, with a market launch scheduled for 1 July 2019, subject to approvals from financial supervisors. However, as interviews conducted for this study confirm, the challenge of attracting interest from major carriers is still likely to be a barrier to its success.

One solution put forward by the proponents of a commodity-style trading model for capacity would be to require large players to market a proportion of their capacity via an

111 See a discussion of earlier bandwidth trading platforms at https://www.capacitymedia.com/articles/3142799/Is-bandwidth-a-tradable-commodity and http://www.vertecto.com/Capacity_June_09_TRADING_PLATFORMS.pdf.

112 Interview April 2019 in the context of this study.

exchange. They cite in support of this argument that certain European countries such as Greece, Poland and Romania have required electricity companies to trade certain types and/or proportions of capacity via an exchange,[113] while in the Nordic Region and other countries such as Spain, Portugal, and Italy, such trading occurs in practice. The trading of capacity on such exchanges, enables matching of supply and demand for electricity, a commodity which cannot be stored in large amounts.[114] Meanwhile, liquidity and competition in supply has been assured in some countries through "reference prices" and obligations on or commitments by major players to trade given amounts of capacity.[115]

Having interviewed a knowledgeable expert in the electricity sector, it is not clear how far the electricity model can be relied on here. The electricity market is complex, with multiple markets and different kinds of markets. There might be points of similarity with roaming, but there are also large differences between the sectors. At the same time, we note that electricity trading has indeed resulted in reasonably good allocative efficiency.

Proponents of trading platform models argue that if a similar approach were applied to roaming markets, it could support effective competition in wholesale roaming capacity, constraining pricing and thus removing the need for wholesale price regulation, or leaving such regulation as a "safeguard". This would require a form of wholesale regulation that would be new to the telecom sector. However, proponents of mobile capacity exchanges argue that the market would likely remain, even if regulation requiring operators to commit a certain proportion of capacity for trading were implemented on a temporary basis.

The concept of trading platforms are welcomed by some MVNOs and smaller mobile operators. However, supporters of platforms are less certain that they would lead to competitive wholesale offers, even if accompanied by regulatory obligations for leading mobile carriers to trade capacity. It should also be noted that the parallels with energy markets are not exact, as already noted, meaning that pricing outcomes obtained in energy might not necessary be replicated in telecom markets. One important difference is that under European legislation,[116] companies engaged in energy supply and generation must be "unbundled" from (operate independently from) the operation of transmission networks. This may limit their incentive to discriminate in favour of their downstream arm and any associated partners, compared with mobile network operators, which generally remain vertically integrated. The limitations on energy storage also provide an incentive for generators to engage in trading (at least for shorter

113 For example, since July 2012, in Romania, under the Energy Act, Article 23(1) all domestic electricity trading on the competitive wholesale market must take place on the power exchange.

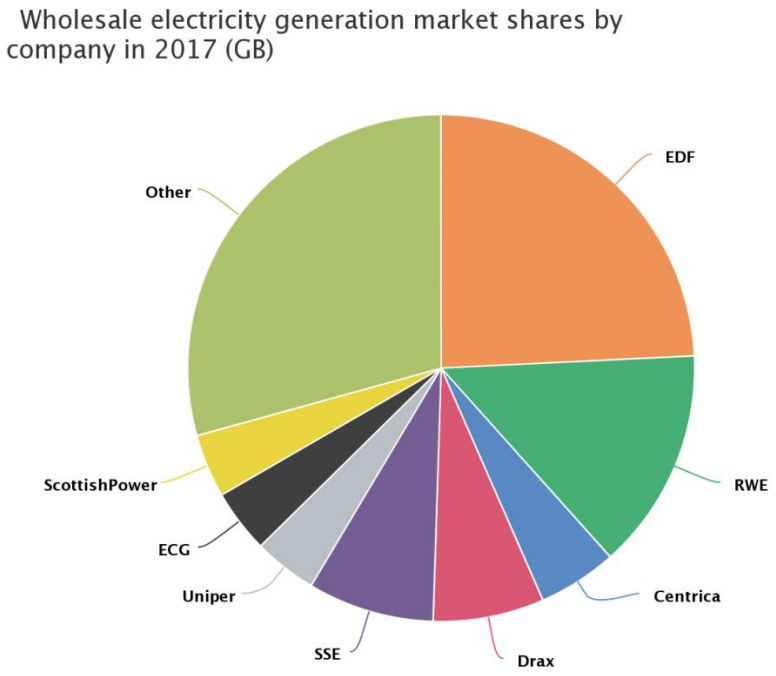
114 See discussion on electricity wholesale markets on the Ofgem website (see https://www.ofgem.gov.uk/electricity/wholesale-market/gb-electricity-wholesale-market).

115 For example in the UK, alongside reference prices, the UK's six largest energy suppliers have committed to trade a proportion of their power station output in the day ahead market https://www.ofgem.gov.uk/electricity/wholesale-market/liquidity.

116 https://ec.europa.eu/energy/en/topics/markets-and-consumers/market-legislation.

term contracts), which does not apply in the same way in the telecom sector. Furthermore, while – due to scarcity of spectrum resources - there are typically only three to four mobile operators in each member state, there can be many more players involved in electricity generation. As an example, the figure below shows the wholesale electricity generation market shares in the UK. The greater range of sources of supply increase the prospect for trading to lead to competitive pricing in energy compared with telecoms.

Figure 2-33: Wholesale electricity generation market shares by company in 2017 (UK)



Source: Ofgem.

On the other hand, it could be argued that if markets for mobile access and origination are considered sufficiently competitive that they can support competitive offers for MVNO access or national roaming, similar competitive intensity amongst mobile operators should in theory be possible for international roaming, if market opening was triggered through a trading obligation.

Aside from the question of whether trading platforms could be a useful measure to facilitate competition in wholesale roaming, it is also worth considering whether digitisation of trading and potentially trading platforms may be necessary to respond to the expected demand for increasingly varied roaming and/or access products that may arise as we move towards 5G and network slicing, and the evolution of M2M services which may have specific cross-border connectivity needs. Although requirements for M2M services are today often bespoke and may involve specialised connectivity

solutions agreed on a bilateral basis, this inevitably limits their geographic reach. The market might therefore benefit from standardised solutions for roaming with QoS parameters, which could then be susceptible to trading.

Given the uncertainties about the potential efficacy of this model as a means to ensure that smaller players or MVNOs can obtain roaming offers on fair and reasonable terms (and indeed questions around the potential role of trading in a more complex environment for roaming/global connectivity), another solution could be to open the door under a future review to set out at EU level, requirements for the trading of roaming capacity, in the event that this solution proves to be effective and efficient. Such an obligation could involve a requirement that MNOs (all or above a certain size) should trade a given proportion of their roaming capacity on an exchange which meets certain criteria.[117]

This effectiveness and efficiency of this solution could be assessed through an analysis of whether:

- capacity trading platforms that are due for launch prove to be effective in lowering prices for mobile capacity including roaming in countries where competition amongst providers exists; and whether
- certain mobile operators unreasonably refuse to negotiate reasonable wholesale roaming agreements with partners of unequal bargaining power, which could be assessed for example with reference to the level of prices offered compared with average negotiated prices, and/or in relation to cost estimates; and whether
- the result is that competition in the provision of EU-wide mobile roaming services is undermined.

2.2.5 Local break-out

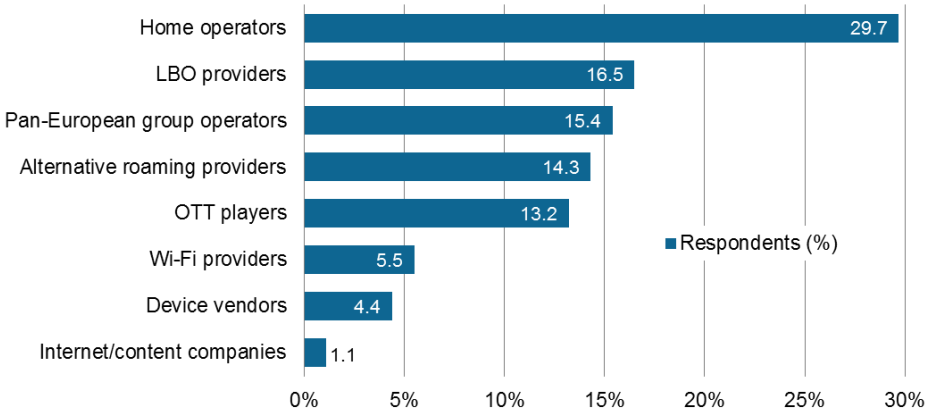
'Local Breakout' (LBO) is a solution to offer roaming data services without the need to route the traffic back to the home network.

The roamer is enabled to use its own SIM-card in the visited country. He has to sign a contract with the LBO operator and pay directly to him.

Therefore, LBO could provide business opportunities for different types of providers. A survey from Informa in 2013 indicated that several players could profit from LBO roaming solutions (see Figure 2-34) and would increase competition in roaming.

117 For example, criteria could relate to the recognition of such exchanges by relevant telecoms and/or financial regulatory authorities, the requirement for trades to be anonymous and for inbound and outbound traffic to be sold separately.

Figure 2-34: Survey about LBO (2013): Who is better placed to control inbound roamers under Local Break-out?



n=91 (Operators & MVNOs)

Source: Informa.[118]

In the EU, the Roaming Regulation of 2012 attempted to enable roaming competition based on LBO (and Single IMSI as well). BEREC provided the related guidelines to enable implementation of these structural solutions. But then, the Commission proposed its Telecoms Single Market (TSM) legislative package in 2013, which called for rapid abolition of roaming surcharges. This unexpected change undermined the prospects of a profitable business model for the structural solutions before they had even come fully into force.

Today, technical specifications are in place,[119] and the related investments have been made by various stakeholders. Solutions for LBO have been developed by various companies, among them Tango Telecom from Ireland[120].

Nevertheless, mobile operators seem to not have deployed these solutions to a larger extent yet, either in Europe or in the rest of the world.

LBO development has been monitored in the context of the European review of the roaming market. In 2016, the BEREC International Roaming Benchmark identified only one operator offering LBO services in the EU member states.[121] This operator from

118 See Informa (2013): Next Generation Roaming: Service Evolution and Innovation - Opportunities and challenges for operators amid technical and regulatory change https://www.gsma.com/futurenetworks/wp-content/uploads/2013/11/Tata-Next-Gen-Roaming_v4.pdf, page 7.

119 See e.g GSMA (2018): IMS Roaming, Interconnection and Interworking Guidelines, Version 28.0, 02 May 2018, https://www.gsma.com/newsroom/wp-content/uploads//IR.65-v28.0.pdf.

120 See http://www.tangotelecom.com/dre-for-roaming-monetisation.

121 See BEREC (2016): BEREC Benchmark Data Report April – September 2015 BoR(16)28, page 11.

Lithuania (Cheap Data Communications) claimed to be the first LBO provider in the world.[122] However, it seems that it does not exist anymore, at least not in its original format.

A report of the European Commission confirmed that it was very unlikely that LBO would develop to any significant extent in the EEA by the time of implementation of RLAH in June 2017.[123]

eSIM might enable new opportunities to implement LBO solutions. However, interviews conducted for this study did not reveal significant interest amongst major mobile operators in targeting this market. Moreover the challenges of switching to an LBO provider for roaming would multiply any challenges associated with switching on eSIM platforms as switching would need to be performed for each country visited, and there could also be challenges associated with marketing, and abiding by requirements for customer identification and authentication, which are subject to differing regulations in different countries. In this respect, specialised roaming providers like Gigsky and Truphone have a competitive advantage in usability compared with LBO via eSIM as they have to be downloaded and activated only once in order to access local networks in various countries.

2.3 New business models and players in the roaming space

As discussed in the previous section, technological developments such as eSIM could open up the roaming market to new entrants in the provision of consumer roaming as well as global connectivity for devices and IoT.

New platforms at wholesale level could also emerge (with or without the support of regulation) to support the ability of these providers to purchase capacity flexibly across multiple countries.

In this section, we explore what role non-traditional mobile operators could play in cross-border connectivity going forwards. We also discuss in this context, how the role of traditional mobile operators could evolve.

122 See Startup Lithuania (2015): Lithuanian Startup Widerfi Enters the World's largest accelerator, 27 May 2015, https://www.startuplithuania.com/news/lithuanian-startup-widerfi-enters-the-worlds-largest-accelerator/.

123 See European Commission (2016): COMMISSION STAFF WORKING DOCUMENT Accompanying the document "Report from the Commission to the European Parliament and the Council on the review of the wholesale roaming market" {COM(2016) 398 final} Brussels, 15.6.2016 SWD(2016) 200 final https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2016:0200:FIN:EN:PDF page 64.

2.3.1 Mobile virtual network operators, enablers and aggregators

One group of operators that could benefit of the opportunities offered by eSIM and IoT are operators which aggregate connectivity across multiple jurisdictions to provide a seamless mobile virtual network. These players are sometimes referred to as multi-national MVNOs when they provide services directly to end-users or MVNEs/As, when they act as middlemen, providing mobile connectivity to mobile resellers or industries engaging in IoT.

In recent years, this business model has expanded as MVNO/As succeeded in winning important contracts with large automobile manufacturers to provide in-car connectivity (fe.g. Truphone's with Kia, Cubic with Audi).[124] Players such as Transatel have also increasingly moved into the IoT space. Analysis Mason estimated in 2018 that at least 20 firms (excluding MNOs) are offering worldwide or regional IoT connectivity.[125]

The potential to use a secondary data connection for roaming through eSIM also provides scope for MVNO/As to gain more of a foothold in the consumer roaming market. MVNO/As such as Truphone and Gigsky have taken advantage of this opportunity.

2.3.1.1 Truphone

Truphone is a full service provider in the enterprise customer market. It was founded in 2006 and has coverage via MVNO agreements in 8 countries including 5 (soon to be 6) European countries. Until recently, it did not play a significant role in the consumer segment.

However, the launch of eSIM on the iPhone and iPad enabled Truphone to make a play for the consumer market by offering ‘applications’ for roaming, which offer a considerably more user-friendly solution to bypass the host operator than was possible in the past. Truphone describes eSIM as a “fantastic enabler” – opening the way to much more straightforward connectivity than Wi-Fi connections, which require configuration in each case.

Truphone notes that eSIM activation is still relatively limited, but that is to be expected in view of the fact that eSIM was launched in the iPhone only in September 2018 and many customers are unaware of the opportunities it provides.

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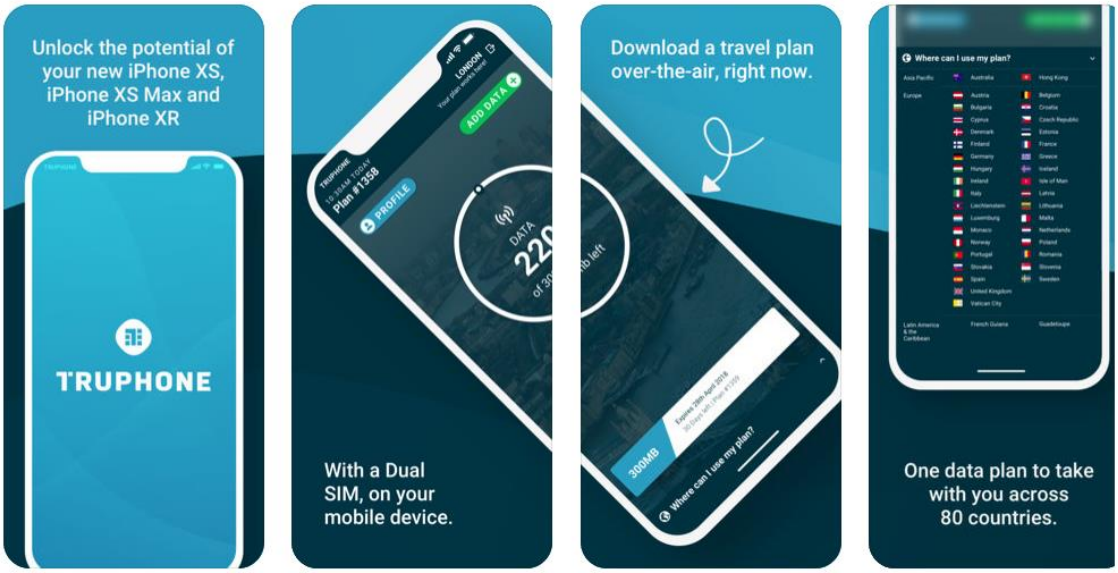
124 See Analysis Mason (2017): Predictions for IoT: investments in NB-IoT, LTE-M and new capabilities prepare operators for an active 2018, 18 December 2017, http://www.analysysmason.com/predictions-2018-iot-rdme0.

125 See Mackenzie, M.; Rebbeck, T. (2018): Contract wins by IoT MVNOs mean they should not be ignored by MNOs, February 2018, http://www.analysysmason.com/IoT-MVNO-contracts-RDME0/.

Truphone is making data tariffs available to 80 countries worldwide for eSIM-enabled iPhone models via the MyTruphone App (see Figure 2-35). For these countries uniform data tariffs apply, for a service life of 30 days, 1 GB for 15 Euro or 3 GB for 42 Euro can be booked, for one day 300 MB are available for 6 Euro.[126] Truphone data plans are also available covering 40 countries through iPad models equipped with the Apple SIM.[127]

The eSIM is preinstalled in the smartphone. It provides a global bootstrap for Truphone. Wherever the consumer wants to activate the eSIM in the smartphone, a local profile is downloaded onto the device. Truphone has the processes in place to ensure that the device can be connected. Truphone claims that the process is simple – especially compared to the offers of MNOs who currently provide eSIM in a more complicated way than traditional SIM. Truphone claims that through its application it should be possible to set up a profile in minutes. Purchasing services thereafter could take a few seconds.

Figure 2-35: Truphone App for activating the eSIM in iphones



Source: Apple, https://itunes.apple.com/app/my-truphone/id1369080719.

Truphone notes that eSIM has also revolutionized the provision of services for corporations. The enterprise customers on its network have not received plastic SIMs since December 2018. Instead they can download eSIM profiles and add new subscriptions at will. This has eliminated the logistical complexity of making changes. The replacement of plastic SIMs with eSIMs could also reduce waste.

126 See https://www.truphone.com/iPhone-xs-dual-sim-plan/.
127 https://www.truphone.com/apple-sim/.

Truphone's CEO Ralph Steffens predicts that in time, all tablets will be cellular enabled, as the prices for cellular modules decline. Cellular connectivity will also be supported by plans which allow for companion devices including watches, laptops, tablets and other devices in the home. Steffens observes that companies like Truphone could lead the way in providing this kind of connectivity because they have global infrastructure. While MNOs may have a global brand, they have multiple domestic networks, he notes. Because Truphone has built a single global network they could create an offering in every country in the world where full wholesaling is permitted.

Truphone is able to rely on its MVNO agreements in 9 countries to avoid the need for roaming, but it relies on roaming in other cases to provide comprehensive coverage. Their preferred approach is to reach direct roaming agreements with the operators concerned. However, they also use "sponsored" roaming agreements (making use of MNOs roaming deals) to cover the "long tail" of areas where they have limited business. In most cases, Steffens reports that MVNO or roaming agreements can be reached on a commercial basis. However, Truphone notes that there can be difficulties in markets with less competition, for example where operators have been reduced from 4 to 3. In these cases, even where the NRA has encouraged or required MNOs to offer MVNO services, often only light MVNO is offered, which does not support Truphone's business and service model.

Although Truphone can obtain roaming rates below the wholesale regulated caps in many cases, they note that their ability to reach settlements could be affected in countries where wholesale competition is more limited, and the wider effects of removing the regulated cap could be unpredictable.

Another area in which they suggest a need for regulatory attention is on access to new technologies which are underlying advances in IoT. Truphone notes that it must negotiate with every carrier to have access to technologies such as LTE-M and NBIoT. This limits their ability to supply services that need to be used in multiple countries. They also foresee challenges in accessing the capabilities of 5G, as MNOs try initially to harness the benefits of this technology for themselves. Truphone suggests that a principle that would oblige operators to provide equal access to wholesale partners for the latest technologies could accelerate the development of new business models.

2.3.1.2 Gigsky

Similar to Truphone, the global roaming provider ***GigSky,*** founded in 2010 and based in the Silicon Valley, offers data tariffs to around 190 countries worldwide for the new iPhone models.[128] GigSky offers 6 multi-country regional plans (North America, Europe, Asia, Latin America, Caribbean, Middle East/Africa). Those regional plans have

128 https://www.gigsky.com/gigsky-iphone-xs-max-xr-cellular-data-only-plans/.

the same pricing, e.g. 300 MB at 10$/1 day, 500 MB at 15 $/15 days, 1 GB at 20$/15 days, 2 GB at 30$/15 days, 5B at 50$/30 days.[129] In addition, Gigsky also provides roaming services for the Mobile Plans App of Microsoft. In September 2018, it acquired Simless, a digital SIM card technology to operate an own subscription management platform for eSIM procurement, remote management and customizable apps.[130] The platform provided by GigSky is compliant with GSMA specification.

2.3.1.3 Transatel

One of the best-known MVNA/Es is Transatel, which has been present in the European market since 2000.

Initially Transatel's business model focused on offering cross-border solutions for frequent travellers, in the UK, France and Benelux region through a network of MVNO arrangements. Transatel subsequently adapted its business model to become a mobile virtual network "enabler", supporting MVNO solutions for other brands in the UK, France, and Belgium.

Transatel has since expanded into a global connectivity solutions provider, and in 2014, it entered the IoT space, using its MVNO coverage (with complementary roaming agreements) to support connectivity for tablets, as well as other connected things including vehicles and aircraft.

Transatel provides connectivity through a set of more than 100 agreements covering 140 countries with comprehensive coverage especially in America, Asia and Europe. The agreements reached constitute MVNO access from a regulatory perspective, and Transatel must comply with local regulations in this capacity. However, the agreements make use of roaming as a technical solution, to benefit from the high degree of standardisation.

Key clients for Transatel's global connectivity solutions include car manufacturers such as Jaguar Landrover in the UK. Airbus also uses Transatel SIMs for predictive maintenance of planes while Easyjet and Delta planes are also equipped with Transatel SIMs. Transatel SIMs are also provided in Microsoft tablets and the company has agreements to provide SIMs for laptops manufactured by Lenovo and Asus.

Transatel considers connected devices (other than smartphones) and IoT to be a fast growing business. While its MVNO data volumes have increased 10% year on year, IoT volumes for the company have been growing 20% each month.

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129 See Gigsky: iphone dual sim plans, https://www.gigsky.com/gigsky-coverage-and-pricing-for-iphone-xs-xs-max-and-xr/.

130 See Gigsky (2018): GigSky Acquires Simless to Help Drive Global eSIM IoT Adoption, 06 September 2018, https://www.prnewswire.com/news-releases/gigsky-acquires-simless-to-help-drive-global-esim-iot-adoption-300707696.html?tc=portal_CAP.

Transatel sees the interpersonal mobile connectivity business and IoT business as separate and distinct. While it has faced challenges in negotiating roaming rates below the regulated caps for its consumer MVNO business, it has had more success in negotiating agreements to facilitate the IoT business, because the carriers perceive it as additive rather than as a competing service. Another key difference is that IoT services are often cross-border or global, and require a uniform approach, in its view.

Transatel sees eSIM as an important opportunity to foster connectivity and competition in service provision to devices such as tablets and laptops, which have not previously had mobile connectivity. It will also have an important application for connected cars. However, Transatel's CEO considers that eSIM is likely to have fewer implications on competition on mass-market roaming, and considers that having a second roaming provider will be a niche market, while switching to local mobile providers on arrival could create identification and security concerns.

As regards 5G, Transatel CEO Jacques Bonifay sees opportunities for MVNOs to take greater control over network functions and provide further innovation in the IoT space, if they are able to define and take control of network slices. However, there is a risk that it may prove challenging to extend existing MVNO agreements to the next generation. Bonifay notes that it will take some time for 5G roaming principles to be defined, as 5G is still not yet deployed at a national level. The main change is likely to be in the charging principles. Whereas in Europe, data is charged per Megabyte, in Japan, charging is based on given bandwidths.

2.3.1.4 Prospects for multi-national MVNOs, MVNA/Es

The potential for MVNA/Es to gain share in an eSIM enabled environment appears significant, especially for emerging markets delivering connectivity for IoT, as well as connectivity for tablets and laptops via collaboration with device manufacturers .

There may also be opportunities facilitiated through eSIM enabled smartphones, for multi-national MVNO players to gain an increased foothold in roaming traffic, if mobile operators do not react to the threat by maintaining attractive offers.

However, the business models of these players are dependent on the potential to negotiate attractive MVNO access or roaming arrangements with providers in multiple countries. This may be possible in countries and cases where their business is additive, but may be challenging in circumstances where their business could compete with that of host operators.

For services where customers can make an active choice in their provider, these players may also be reliant on how eSIM is implemented and the degree to which MNOs – and indeed device manufacturers, support switching and allow them to effectively market their services.

2.3.2 The role of verticals in global connectivity/IoT

There is an increasing demand for mobile connectivity in the IoT space. This is true especially for connected vehicles. However, there are a number of uncertainties about how this will evolve and who will provide the connectivity. Although the volume of data that a connected car can generate per day is significant, much of this information will never need to traverse the broader mobile network. For instance, much of the data might be used only locally for purposes of collision avoidance.

Our interviews suggest that the commercial arrangements might depend heavily on the nature of the service in question, and on who gets to choose the service provider. When it comes to entertainment video in a connected car, for instance, a consumer might be more likely to choose a mobile network operator which it trusts and with which it has experience. For telemetry data (typically using a different SIM), however, the manufacturer is likely to choose.

While some car manufacturers have outsourced their connectivity needs to companies such as Transatel (see above) or to mobile network operators such as AT&T,[131] the move towards connected mobility and IoT more generally could provide opportunities for vertical industries to invest directly in connectivity platforms.

We are not aware of examples of car manufacturers directly acting as large-scale MVNOs today, and the complexities of organising multi-national MVNO and/or roaming agreements are likely to deter car manufacturers or other IoT manufacturers from entering into global connectivity directly. However, it is noteworthy that in 2015 Audi co-invested €18m, together with Qualcomm, in Cubic Telecom, an Irish company focused on offering connectivity to the automotive sector.[132] Audi reported at that time that it had acquired a strategic minority interest in the company, and promised to "work together on a wide range of future connectivity applications".[133]

Cubic launched in 2009 as a global platform provider, offering software and platform services to multi-national companies. In Europe, Cubic Telecom's most prominent client is the Volkswagen Group, which uses its eSIM technology and services in many of its Audi and Volkswagen models. Cubic has also recently signed contracts to connect Skoda[134] and to support Microsoft's Connected Vehicle Platform.[135] In January 2019, Cubic reported that more than 2m cars were using its connectivity technology.[136]

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131 See https://about.att.com/story/2018/commitment_to_connected_car_technology.html.
132 https://www.prnewswire.com/news-releases/cubic-telecom-secures-eur18-million-co-investment-from-audi-and-qualcomm-inc-300078272.html.
133 https://www.audi-mediacenter.com/en/press-releases/audi-and-cubic-telecom-start-strategic-partnership-2303.
134 https://www.cubictelecom.com/Media/PressRelease/44.
135 https://www.cubictelecom.com/Media/PressRelease/43.
136 https://www.siliconrepublic.com/machines/cubic-telecom-connected-cars-ego-european-ev-fleet.

They offer a full spectrum of services for connected driving ranging from telematics to in-car infotainment. Services to aid drivers include navigation and locating available parking spots, as well as charging stations for electric cars. However, the most popular services are music streaming and digital radio, which is often used to continue listening to national stations when customers leave their radio spectrum coverage area. Connectivity is not the core service provided by Cubic, but is often taken alongside their platform and software services.

When offering connectivity, they need to accommodate different network partners, regulations, as well as varied operator policies. They combine roaming using their own network codes and sponsored roaming with (increasingly), MVNO-based solutions. The choice of using MVNO access vs roaming is driven by a number of factors, including the regulatory requirements in the countries concerned e.g. whether the countries forbid the use of foreign IMSIs for permanent roaming.

Cubic notes that one benefit of roaming is that it offers a standardised solution. However, because roaming was not intended for industrial IoT solutions, it is not suited to the stringent QoS requirements needed for the automotive industry. The emergence of roaming products for IoT with service level support would be a positive development.

Cubic believes that 5G deployment will take some time, with roaming on 5G coming after national deployment. They have an interest in network slices with specific performance capabilities, and note that smaller and national operators may have an interest in developing wholesale offers.

Similar to feedback gained from other MVNO/As specialised in IoT connectivity, Cubic does not report specific challenges in securing commercial wholesaling or roaming agreements. However, they consider that the market has been supported by the presence of the existing regulated access to roaming services.

Arrangements such as that by Cubic/Audi suggest that car manufacturers and other verticals could play an active role in cross-border connectivity as investors or co-investors together with other experts in the sector. Such a business model could enable them to bargain with multiple mobile operators for access at a national level rather than relying on (and potentially risking tie-in) to access from a single mobile network operator.

The experience of Transatel in negotiating on behalf of car manufacturers suggests that they may be able to secure access deals on reasonable terms, as their traffic is additive to that of national mobile operators rather than acting in competition to their main business model today. However, it is notable that as of 2018, Cubic Telecom, which

focuses on the automative sector, was still loss-making.[137] It is not clear to what extent this may have been due to difficulties in securing wholesale or roaming arrangements, or is due to other factors.

2.3.3 The role of equipment manufacturers and OS providers in global connectivity

As discussed in Section 2.2.2, certain equipment manufacturers such as Apple have played a pioneering role in promoting global connectivity solutions.

Apple's first foray into global connectivity was the Apple SIM, which was installed in 2014 in the iPad Air 2 and iPad Mini 3 and targeted towards in the UK and US. Apple coupled the technology with an MVNO platform which allowed wireless network operators to bid for the right to provide their services to Apple. The Apple SIM enabled customers to choose a network operator dynamically – directly from the device.

Most market experts agree that the impact of this service was quite limited. However, as eSIM spreads to smartphones as well as devices which were previously not equipped with SIMs, Apple, as well as well other equipment manufacturers and operating system providers are likely to play an increasingly important role in fostering demand for and facilitating global connectivity (see case studies on Apple and Microsoft in Section 2.2.2.2).

Although operating system providers such as Google have experimented with offering their own connectivity service as an MVNO and Wi-Fi aggregator (see discussion on Google Fi at section 2.1.1), interviews conducted for this study suggest that the role of players such as Google, Apple and Microsoft is more likely to be that of facilitators of global connectivity supplied by other players (such as Truphone, Cubic, Gigsky and Transatel) rather than as suppliers in their own right.

The potential for these players to act as marketing agents and potential gatekeepers for the provision of connectivity services and their ability to monetise access provided by others, could impact competition. As there are multiple providers of devices and the involvement of device manufacturers has in practice often enabled entry by newer or smaller connectivity providers which did not previously have a significant share in connectivity, the effect today is likely to increase competition. However, if concerns arise in future, these could be investigated under the provisions of competition law.

137 https://www.irishtimes.com/business/technology/losses-widen-at-fast-growing-tech-company-cubic-telecom-1.3760064.

2.3.4 The role of communication application providers

As discussed in Section 2.1.2, voice, video and messaging application providers such as Facebook (with its WhatsApp service) are likely to continue to play a significant role in offering alternative communication services to those provided by mobile network operators. As such it is possible that they could promote innovation in managed communication services and constrain the ability of mobile network operators to charge excessive prices for these services.

As application providers such as these have strong brand recognition, they have the potential to leverage their brand into provision of connectivity, based on MVNO access. However, from the interviews conducted for this study, there was no indication that these players have specific plans to launch such services in the market (whether in Europe or otherwise) in the short to medium term.

2.3.5 The role of mobile network operators in global connectivity

Mobile network operators at a national level will continue to hold the key to the provision of mobile services in their coverage area due to their ownership of spectrum. Thus, they will continue to play a pivotal role in the provision of cross-border connectivity, whether as providers of global connectivity and communications services to end-users or as wholesalers of access or roaming.

Different players have differing visions of the roles that mobile network operators may have in an environment of global connectivity. Larger groups often see themselves as significant players in both supplying services to customers such as RCS and engaging in the expanding market for IoT connectivity. However, in the context of interviews conducted for this study, we noted that smaller players could also see an increasing role for themselves as wholesalers of bandwidth to national MVNOs and trans-national/global retail service providers. It is possible that a mix of business models could emerge as different players in the mobile market seek to leverage their specific strengths.

3 Assessing the competitive impact of technological and market developments and implications for regulation

3.1 Methodology

When conducting a market review under the procedures of the EU electronic communications Code,[138] it is necessary to first establish, which are the relevant retail markets and the likelihood that in the absence of any intervention, that these markets will tend towards effective competition.

The scope of the market is defined with reference to whether other products could substitute for those currently considered to be in the relevant market (demand side substitution), or whether players in neighbouring markets could readily adjust their offerings to compete in the market (supply side substitution).

Generally, markets are assumed not to be susceptible to ex ante regulation under the Code unless three tests are met (i) high and enduring barriers to entry; (ii) the market does not tend towards competition; and (iii) other interventions, including competition law, would be inadequate to address the problems identified.

If the retail market does not tend towards competition under these criteria, then relevant wholesale markets are identified, and the three criteria test described above is applied to each. Thereafter, if a wholesale market is susceptible to ex ante regulation, it is relevant to consider which actors in the market are able to wield significant market power. This is assessed with reference to whether companies can individually or collectively behave independently of their competitors and ultimately consumers, and is often measured by the ability of undertakings to raise prices above the competitive level without triggering switching, although other factors are also relevant.

Although it is not possible to provide a robust market analysis for a period extending beyond 5 years, it is helpful to consider these principles when assessing at an EU level, whether technological, service or market developments might affect competition and the need for roaming regulation in the medium term.

Drawing on these principles, we have used the following indicators and sources to gauge the degree to which different technologies or other developments might substitute for and/or enable entry and competition with providers of existing roaming products.

138 http://www.europarl.europa.eu/doceo/document/TA-8-2018-0453_EN.html?redirect.

Table 3-1: Indicators to assess potential competitive effect

Indicator	Questions	Source of evidence
Maturity/readiness	Is the technology or service currently in widespread use? If not, will the technology or service be available in a relevant timeframe?	Desk research Survey Interviews
Equivalence	Does the alternative technology or service offer equivalent or enhanced capabilities compared with traditional data, voice and/or SMS?	Analysis of features compared with traditional roaming Survey Interviews
Expansion in supply	Are there undertakings present in the market which are deploying these technologies or services in Europe or elsewhere (where roaming is not regulated)? If not, are there undertakings which would be likely to invest in these technologies or services?	Desk research Survey Interviews
Potential growth in uptake	What evidence is there that customers would use the service instead of voice, SMS or data roaming from their traditional provider? Are there specific dependencies e.g. quality of underlying data transmission for OTT applications?	Data on past record of take-up compared with take-up of potentially equivalent roaming services Analysis of whether increasing take-up is associated with a decline in the use of traditional roaming Survey
Impact of roaming price increases on switching	If there were a small but significant increase in price of relevant roaming services from existing providers, would this lead to an increase in take-up for the alternative provider or technology?	Analysis of whether take-up of the alternative technology or service is higher in countries where roaming prices are higher e.g. non-EU than in countries where roaming is regulated Any evidence of changes in usage aligned with roaming price increases in specific countries

Source: WIK-Consult.

Because the assessment is being made on markets which are currently subject to retail and wholesale regulation, it is necessary to apply the “Modified Greenfield Approach” to the analysis. This means that the assessment is conducted in a hypothetical environment in which existing regulation is not present. Evidence of likely supplier and consumer behaviour in this context must be drawn from cases or times in which regulation is absent, or inferred from scenarios which give insights as to whether customers might switch from one product to another in the event of a price increase.

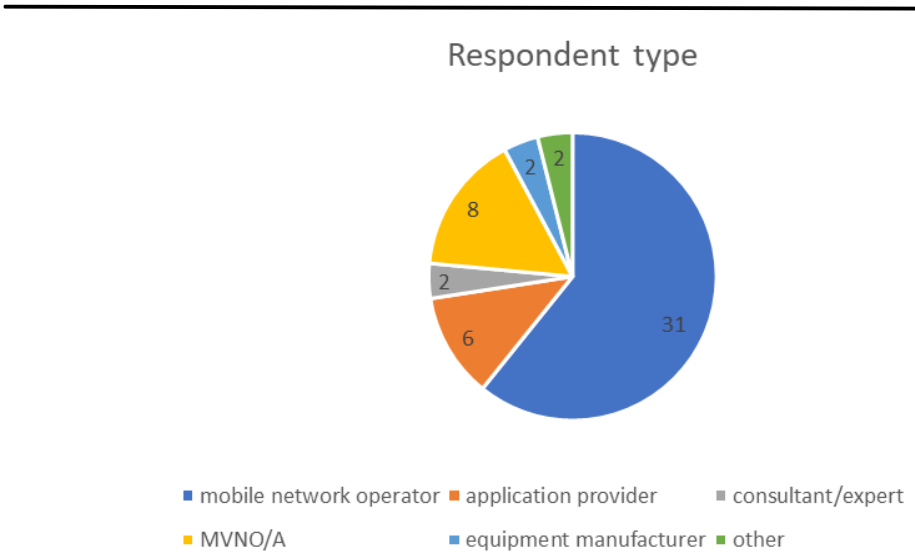
As noted in the table, in addition to examining evidence from usage trends associated with the different technological developments (detailed in Chapter 2), we relied on inputs from interviews and an online survey.

Interviews were conducted between January and April 2019 with actors involved in the main elements of the value chain associated with global connectivity (MNOs, MVNO/As in the consumer, business and IoT segments, application providers, equipment

manufacturers, trading platform providers). The companies interviewed and main interview questions are shown in Annex I.

The online survey was conducted during the first half of March 2019. The survey questions are shown in Annex II. We received 51 responses, but with varying degrees of completeness. A breakdown of the responses by category is shown in the following chart. The majority of responses were given by MNOs. The second largest category of respondents were MVNO/As. We have broken down the survey reactions by respondent type in cases where their perspectives differed significantly.

Figure 3-1: Roaming online survey: respondent type



Source: WIK-Consult.

3.2 Current scope of roaming markets

Under the "Telecom Single Market Regulation",[139] roaming providers are, with certain exceptions, prohibited from setting surcharges in addition to the domestic retail price on roaming customers for roaming calls, SMS and data.

Roaming calls are defined as voice telephony calls made by retail customers which originate and terminate on a public communications network, while SMS messages are those which are "capable of being sent between mobile and/or fixed numbers assigned in accordance with national numbering plans". Regulated data roaming includes the transmission and receipt of MMS messages and involves the use of packet switched data communications by means of a mobile device while it is connected to a visited network.

139 https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32015R2120.

By implication therefore, the retail and associated wholesale markets to which the current roaming regulation applies are identified as voice, SMS and data provided through the cellular service offered by their mobile service provider.

An important question, when considering the impact of new non-cellular technologies and other developments if whether these technologies could substitute for services provided via mobile networks. Any technologies found to substitute in this way would need to be included within a wider relevant market, which would likely be susceptible to greater competitive pressures as a result.

It is also worth noting that the TSM Regulation as amended focuses on regulating retail and wholesale roaming tariffs for *personal communications* i.e. roaming communications which involve human intervention. Although not explicitly stated, the context of the roaming regulation has also been the use of mobile communications by consumers and businesses on mobile handsets, rather than other personal devices.

As available data shows that the number of M2M devices relying on mobile connectivity is likely to expand significantly,[140] it is worth considering, especially in the context of data roaming regulation, whether there could also be competitive issues in the context of M2M roamingIoT.

3.3 Data roaming

In this section we consider what alternative technologies could offer a substitute for mobile data roaming, and which developments could lower entry barriers or otherwise impact competition in mobile data roaming. We also consider in this context whether there are differences in the competitive conditions for mobile data roaming for IoT compared with personal devices.

3.3.1 Scope of the market

The key potential substitute identified for data roaming is Wi-Fi. As described in Section 2.1.1, there likely to be differences in the usage of Wi-Fi at fixed locations (in homes, offices and hotels) compared with Wi-Fi hotspots. As Wi-Fi at fixed locations is already in widespread use and therefore any effects on competition in roaming would already have been reflected in the market, we focus on the potential impact of Wi-Fi hotspots on competition in roaming.

140 See for example Cisco 2018 VNI https://www.cisco.com/c/en/us/solutions/collateral/service-provider/visual-networking-index-vni/white-paper-c11-741490.html.

Table 3-2: Maturity and competitive implications of Wi-Fi hotspots

Indicator	Research findings
Maturity/readiness	Wi-Fi technology is mature and hotspots are in widespread use. In 2017, Western Europe accounted for 48% of the world's Wi-Fi hotspots – around 60m in total.
Equivalence/ enhanced features	Wi-Fi offers equivalent data capabilities to mobile retail roaming and domestic data, and has historically offered higher bandwidths and a greater degree of reliability than mobile data. The performance gap may however be narrowing as mobile performance improves. Cisco projects that average Wi-Fi speeds in Western Europe will reach 49,5Mbit/s by 2022, but mobile speeds could reach 50.5Mbit/s[141] While Wi-Fi hotspots may provide equivalent technical capability to mobile data, they are not equivalent in terms of availability and mobility. Cisco reports that the highest number of hotspots by 2022 will be in hotels, cafes and restaurants, with some growth also in heathcare facilities. Availability in open spaces however remains patchy. Wi-Fi hotspot maps reveal coverage gaps over significant geographic areas, and there may also be issues with seamless handover between hotspots managed by different providers.
Expansion in supply	New business models and suppliers have emerged for Wi-Fi hotspot provision in recent years. For example the Wi-Fi4EU initiative has boosted the role of local Government in hotspot provision, while some fixed broadband providers have utilitised capacity from their fixed customers to provide a network of "homespots". Cisco predicts that public Wi-Fi hotspots including homespots will grow 2-fold from 2017-2022 in Western Europe to reach 132m in 2022. They also predict growth in Poland, Central and Eastern Europe, but the number of hotspots in these areas are projected to reach only 16m by 2022. In order to facilitate seamless use of Wi-Fi hotspots and homespots, some providers have emerged to provide "Wi-Fi aggregation" services, for travellers. Examples include the FON network,[142] encompassing 21m hotspots globally, as well as Google Fi.
Potential growth in uptake	Available data suggests that a high proportion of "mobile" data (i.e. data accessed from mobile-capable devices) is already offloaded to Wi-Fi. Projections from Cisco suggest that Wi-Fi use from mobile devices will continue to expand, such that it may account for 32% of all global Internet traffic by 2022 and 60% of traffic from mobile enabled devices by 2022. Surveys suggest relatively high customer usage of Wi-Fi hotspots, with up to 70% of mobile users reporting using them. However there is limited available data on the proportion of that Wi-Fi traffic deriving from Wi-Fi hotspots as opposed to the connections within buildings that are already prevalent today. Uptake will in any event be constrained by availability.
Impact of roaming price increases on switching	Available data suggests that customers with pay-as-you-go mobile data plans tend to make greater of Wi-Fi than those with unlimited plans. This is suggestive of substitution between the two technologies. However, such substitution is dependent on the availability of Wi-Fi hotspots at reasonable cost.

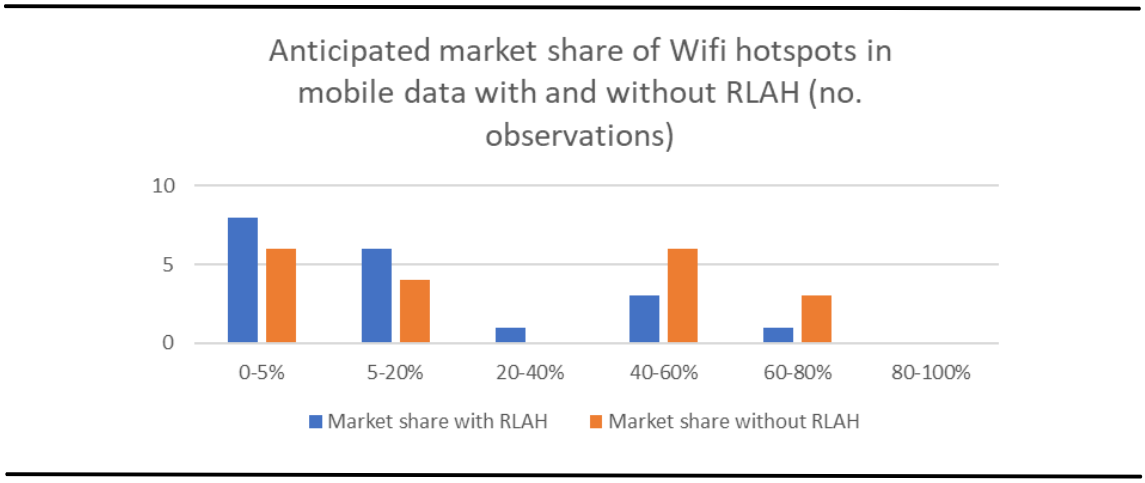
Source: WIK-Consult.

In the stakeholder survey, Wi-Fi hotspots were considered to present less of a competitive challenge to traditional mobile operators than other developments such as eSIM. Respondents considered that Wi-Fi hotspots presented some competitive challenge to mobile data for mobile handsets and other personal devices, but limited challenge for the purposes of connectivity for IoT and M2M.

141 Cisco 2018 VNI.
142 https://fon.com/.

Responses to the survey nonetheless suggest that stakeholders consider that the removal of retail roam like at home regulations could increase the market share of Wi-Fi hotspots in the provision of roaming data services.

Figure 3-2: Anticipated market share of Wi-Fi hotspots in mobile roaming data provision in the presence and absence of RLAH



Source: WIK-Consult based on stakeholder survey, n=38.

In conclusion, Wi-Fi hotspots are expected to offer a partial, but not full substitute to mobile data roaming for mobile handsets and other personal devices, but not IoT. The potential of Wi-Fi hotspots to constrain the prices charged for mobile data roaming may be limited by the patchy availability of Wi-Fi and potentially challenges in handover between service providers.

It is therefore reasonable to expect that there may be a distinct retail market for mobile roaming data/cross-border connectivity in the medium term.

3.3.2 Developments impacting competition in mobile data roaming

3.3.2.1 Implications of eSIM

Retail roaming data services are currently predominantly provided by the host MNO with the subscriber as a “captive audience”, a key cause of market failure in this segment. However, the deployment of eSIM provides an opportunity for end-users to select a different data roaming provider while maintaining their existing number. The installation of eSIMs in M2M devices and other personal devices such as tablets also provides an opportunity for new markets and competitive models to emerge.

Our analysis of the potential impact of this technology is shown in the table below, based on evidence gathered from desk research and interviews (see Section 2.2.2).

Table 3-3: Maturity and competitive implications of eSIM

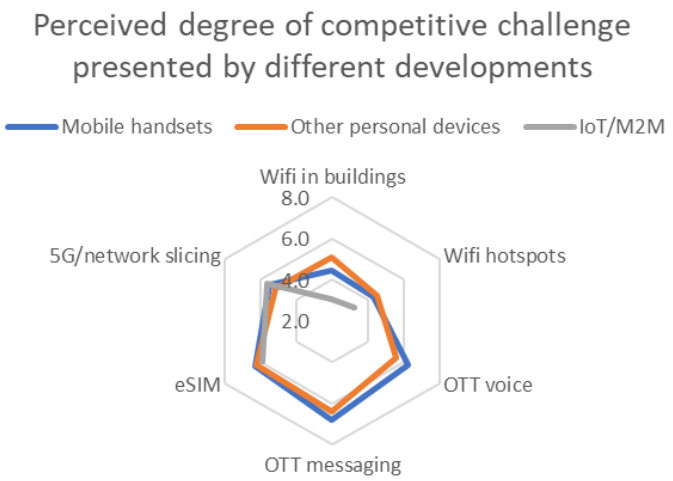
Indicator	Research findings
Maturity/readiness	eSIM standardisation is far advanced: A first architecture for eSIM in M2M was published by the GSMA in December 2013. A separate specification for the consumer sector was released in August October 2016. Meanwhile, uniform technical architectures and interfaces have been developed for both areas. However, the GSMA specification is constantly evolving. In the M2M segment, eSIM has been implemented for several years. Proven use cases have emerged for example in the field of connected cars. Although there are standards available, in the consumer segment, eSIM is still at a very early stage. The launch of eSIM in premium smartphones in September 2018 (some Apple iPhone models) can be regarded as a major step.
Equivalence/ enhanced features	Based on eSIM,, equivalent capabilities can be offered in relation to traditional data, voice and SMS services. With regard to roaming, eSIM supports the take-up of alternative offers more conveniently than those based on traditional SIM cards. The complexity of existing alternative roaming offers could be reduced, as no specific SIM cards need to be created and there is no need for a physical switching of SIM cards. Over the air activation also offers significant benefits for IoT/M2M deployment compared with traditional SIMs and facilitates switching between providers.
Expansion in supply	Equipment manufacturers are progressively deploying eSIM. In total, we estimate about 1,4 million eSIM enabled devices (consumer and M2M) by 2030. eSIM has supported the entry and expansion of specialist MVNO/A players such as Truphone, Cubic and Transatel into markets for global IoT/M2M connectivity and global connectivity for newly mobile-connected personal devices. Some service providers such as Truphone and Gigsky have also exploited the capabilities of eSIM to support a secondary roaming provider. eSIM could in theory also support local break-out, enabling MNOs in visited countries to compete for roaming services. However, interviews suggest limited interest from MNOs in this business model at this stage.
Potential growth in uptake	Take-up of eSIM in IoT/M2M is accelerating. By 2030 about 744.000 eSIM in IoT/M2M can be expected to be in use. Conversely, since eSIM has not been available for personal devices for long, there is limited evidence of take-up in this field as yet. WIK estimates that by 2030 about 400.000 consumer devices with eSIM will be activated, i.e. about 60% of eSIM equipped consumer devices. This number is highly uncertain and will depend on the strategy of players (e.g. related to ease of use) and customer acceptance.
Impact of roaming price increases on switching	It can be assumed that an increase in roaming prices from existing providers would provide an incentive for consumers to use eSIM-based roaming offers. The greater use of multi-SIM devices in regions which do not benefit from roaming regulation is suggestive of this.[143] Greater ease of use for eSIM and the development of apps facilitating alternative connectivity means that its impact is likely to be greater than that seen in such regions. However, due to the early stage of eSIM-penetration there is no empirical evidence yet of the scale of this effect.

Source: WIK-Consult.

In the stakeholder survey, eSIM was cited as one of the developments most likely to pose a competitive challenge to traditional roaming supplied by MNOs. Respondents suggested that this may be the case for mobile handsets and other personal devices as well as IoT/M2M.

143 See for example high levels of dual SIM devices in countries such as India, Nigeria and Brazil https://deviceatlas.com/blog/dual-sim-smartphone-usage-2017.

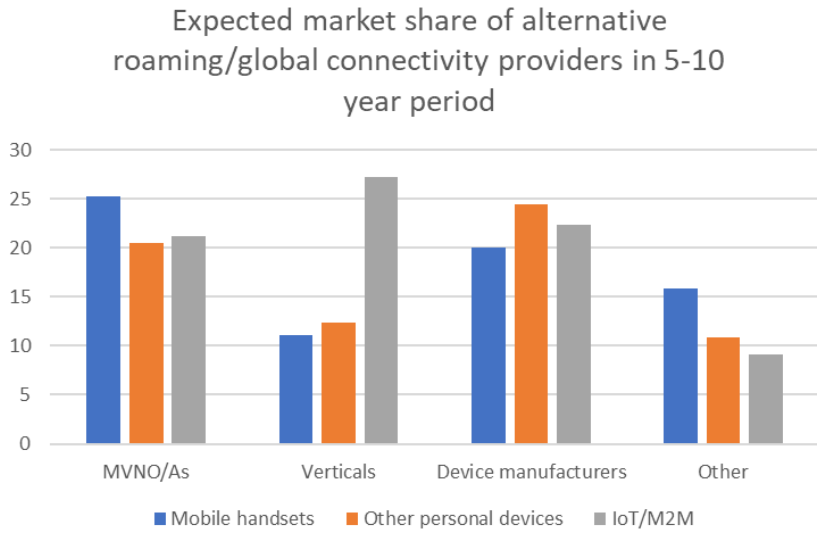
Figure 3-3: Perceived degree of competitive challenge presented by technological, market and service developments (1= limited competitive challenge, 10=significant competitive challenge)



Source: WIK-Consult based on stakeholder survey, n=31.

Respondents to the survey expect that the main players making use of this technology to challenge existing MNOs will be MVNO/As, device manufacturers and (for IoT/M2M), verticals such as car manufacturers (see figure below).

Figure 3-4: Expected market share (%) of alternative roaming/global connectivity providers in 5-10 year period

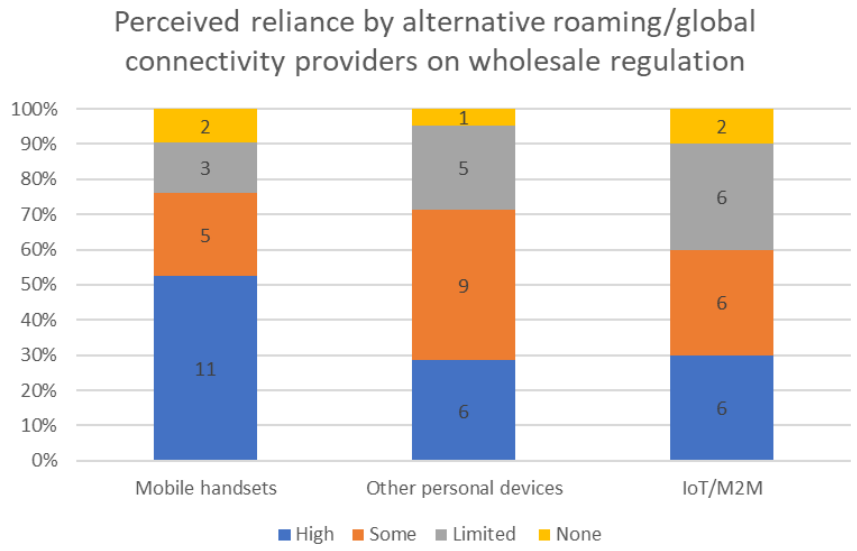


Source: WIK-Consult based on stakeholder survey, n=19.

However because mobile connectivity requires spectrum, competitive challengers to the MNOs are reliant on the conclusion of wholesale roaming and/or MVNO agreements in order to provide multi-national retail services. In a market in which all data roaming regulation (retail and wholesale) were removed, results of the survey as well as interviews suggest that MVNO/As might face challenges in securing appropriate wholesale agreements in certain cases and countries – and especially in relation to roaming for mobile handsets, where they could pose a direct competitive threat to the host MNO.

The chart below shows the perceived reliance by alternative roaming/global connectivity providers on wholesale regulation. For handsets, more than 75% of respondents considered that these providers would be highly or somewhat reliant on wholesale regulation. The reliance of these players on wholesale roaming regulation for the provision of connectivity for IoT/M2M was considered to be less, although half of respondents still considered that wholesale regulation would be needed for this purpose also.

Figure 3-5: Perceived reliance by alternative roaming/global connectivity providers on wholesale regulation (number of responses and % of total)



Source: WIK-Consult based on stakeholder survey, n=21.

In conclusion, we expect that eSIM is likely to have a material impact supporting competition for retail data roaming in the IoT/M2M segment in the medium term. It could also (to a lesser extent) support the development of retail competition in the handset and personal device segments. However, it seems unlikely, at least in case of provision for handsets and other personal devices, that the market would be effectively competitive in the absence of wholesale data roaming regulation.

3.3.2.2 Implications of 5G/network slicing

Another development that is considered likely in the medium term to impact the competitive dynamics of retail roaming data markets is 5G and associated network slicing technologies. 5G and network slicing was considered by respondents to the online survey to be the third most significant development impacting competition in mobile roaming in the medium term, after OTT services and eSIM (see Figure 3-3).

An overview of the status of 5G deployment and expectations in the coming 5-10 years is shown in the table below.

Table 3-4: Maturity and competitive implications of 5G/network slicing

Indicator	Research findings
Maturity/readiness	3GPP Release 15 standards have already been frozen, with final completion expected in June of 2019. 3GPP Release 16 is expected to complete in June 2020.[144] Release 15 already contains substantial capability to support network slices with differentiated Quality of Service (QoS).[145] Many trials of 5G capabilities have been conducted or are ongoing. Providers of 5G equipment can be expected to deploy corresponding equipment as quickly as they reasonably can. Delays are however likely on deployment of slices with differentiated capabilities on the part of vertical market segments. Business models are still in flux.
Equivalence/ enhanced features	Different modes of use offer different benefits. • For enhanced Mobile Broadband, performance benefits. • For IoT, the ability to use slices to customise service characteristics to meet the needs of the devices. • The ability of visited networks to offer slices as an alternative to wholesale roaming services.
Expansion in supply	There is no technical impediment to deployment of general enhanced mobile broadband (eMBB) 5G services; however, some market players do not expect a very rapid deployment. Use of 5G for verticals is likely to be substantial in the medium term, but large scale use of slices with differentiated capabilities is unlikely in the next three or four years.
Potential growth in uptake	For consumer eMBB use, consumer take-up depends on availability of handsets and deployment by MNOs, and might follow trends similar to those of previous mobile generations. For ioT, use cases such as connected cars might drive substantial use in the medium term.[146]
Impact of roaming price increases on switching to 5G/ slicing as alternative	There are a number of existing technologies which support IoT applications such as LTE-M. However, 5G network slicing offers enhanced capabilities compared with previous generations that are likely to make 5G increasingly important for connectivity providers in the IoT space. The prospect of using slices could also enable control of QoS end-to-end, rendering it more attractive than roaming offers in which control passes to the visited network.

Source: WIK-Consult.

144 3GPP, “Releases”, https://www.3gpp.org/specifications/releases viewed 1 May 2019.

145 3GPP (2019), “Technical Specification Group Services and System Aspects; Release 15 Description; Summary of Rel-15 Work Items (Release 15)”, TR 21.915 V1.0.0 (2019-03).

146 Frédéric PUJOL, Carole MANERO, Samuel ROPERT, Ariane ENJALBAL, Tony LAVENDER, Val JERVIS, Richard RUDD and J. Scott MARCUS (2019, forthcoming) “Study on using millimetre waves bands for the deployment of the 5G ecosystem in the Union”.

In the near term, early versions of 5G provide roaming just as 4G LTE systems do (using NonStandAlone (NSA) mode). In the medium term, standalone mode use of 5G depends on updated roaming standards. 3GPP Release 15 already accommodates this.[147] More generally, roaming is an industry requirement so it can safely be assumed that deployed 5G products will support roaming.

Demand for roaming or network slices supporting specific capabilities associated with 5G is likely to be most significant in the context of global IoT / M2M applications. Differentiated QoS offered by means of slices might conceivably also become important in time for the competitive provision of connectivity for handsets and other personal devices as expectations concerning mobile bandwidth increase.

It seems unlikely that these new technologies and standards will affect the bargaining power of different existing players compared with today. However, existing players including non-group MNOs in "roaming out" countries and MVNO/As will need to negotiate or update agreements to reflect 5G technologies, and may face similar delays or challenges in negotiating agreements as were experienced for previous generations of technologies. For vertical segments that depend on IoT, it is also possible that new kinds of firms will begin to offer associated communication services, requiring a need for roaming or other forms of access which enable cross-border communications. The degree to which MVNO/As, verticals and any new firms that emerge to serve verticals, can negotiate commercially reasonable terms for 5G roaming (or indeed other forms of access on the 5G network) may depend on the extent to which their services are considered by the host MNOs to be additive or competitive to their own offers.

MVNO/As interviewed for this study considered that in general, MNOs were likely to first aim to develop their own retail offers before developing offers for wholesale access to 5G network slices to other players. In deciding whether regulatory action is needed, a key question for policy-makers is whether any such delay could unduly hamper innovation and competition in retail markets.

Shifting to another area of regulation, it is possible that the priority management that is required for some of the use cases that depend on network slices offering different levels of QoS might run afoul of network neutrality regulations that have been implemented under Regulation 2015/2120,[148] as clarified by the BEREC Guidelines on the Implementation by National Regulators of European Net Neutrality Rules.[149] Briefly

147 3GPP (2019), "Technical Specification Group Services and System Aspects; Release 15 Description; Summary of Rel-15 Work Items (Release 15)", TR 21.915 V1.0.0 (2019-03).

148 European Union Regulation (EU) 2015/2120 of the European Parliament and of the Council of 25 November 2015 laying down measures concerning open internet access and amending Directive 2002/22/EC on universalservice and users' rights relating to electronic communications networks and services and Regulation (EU) No 531/2012 on roaming on public mobile communications networks within the Union, 2015 O.J. (L 310) 1.

149 BEREC (2016), BEREC Guidelines on the Implementation by National Regulators of European Net Neutrality Rules, BoR (16) 127.

stated, traffic prioritisation on the part of the network is in principle permitted where the application requires it; how this relates in practical terms to the 5G traffic management practices in question, however, is not altogether clear. This is not specifically a roaming issue, but it might well have implications for services such as connected cars.

3.4 Voice and SMS roaming

In this section, we consider whether voice and SMS roaming on mobile networks are still likely to be distinct relevant retail markets in the medium term, and consider the prospects for competition to evolve in these markets.

3.4.1 Scope of the market

In the current TSM Regulation, voice and SMS roaming refers to services provided via mobile networks. However, as discussed in Section 2.1.2, consumers and business customers are increasingly making use of OTT voice and messaging services, and there is evidence that substitution may be occurring for some communications, particularly for messaging. In the following table, we summarise available evidence concerning the degree of substitution between “managed” voice and SMS, and similar OTT services.

Table 3-5: Maturity and competitive implications of OTT voice and messaging

Indicator	Research findings
Maturity/readiness	OTT voice and messaging services are well developed in the market, with various offers targeting specific use cases ranging from communications and video-conferencing for business, to closed networks supporting communications amongst friends and family.
Equivalence/ enhanced features	OTT services can be used to provide the same functionality as is provided by managed voice and SMS. Services often also provide enhanced features compared with managed services, for example by enabling video-conferencing, exchange of imagery, links to documents etc. However enhanced features may require a reliable low cost (or flat rate) data roaming (or Wi-Fi) connection to function. There used to be a significant difference between the quality of OTT voice compared with managed voice. However, this seems likely to further diminish as managed voice moves to IP and the quality of data networks over which OTT voice is offered, improves. One key difference is that most OTT services operate on the basis of closed user groups, whereas voice and SMS roaming offer “any-to-any” connections. However, some OTT services are available such as Skype which interconnect with managed services.
Expansion in supply	Many different actors provide OTT voice and messaging services. The technical barriers to entry for provision of these services are relatively low. However, larger well established players benefit from network effects, that make the business case for later entry more challenging.
Potential growth in uptake	The take-up of OTT voice and messaging via mobile handsets has grown strongly in tandem with the expansion in smartphone use. There are however some signs that growth has tapered in recent years (see Figure 2-7).

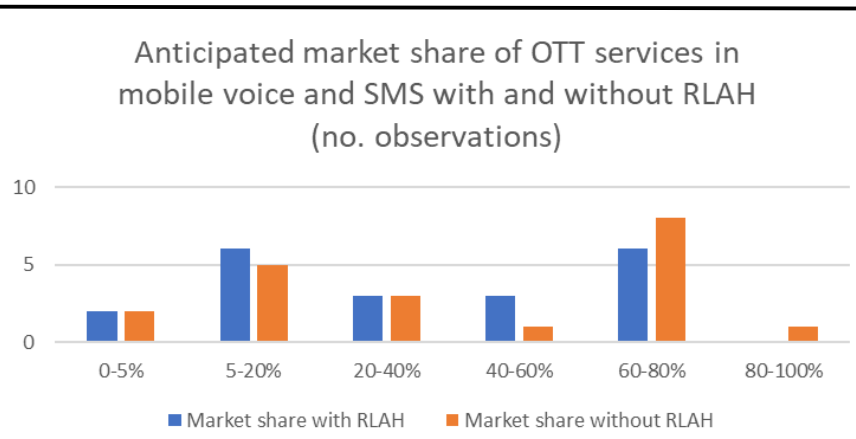
Indicator	Research findings
Impact of roaming price increases on switching to OTT as alternative	Intuitively, it seems likely that an increase in the incremental price of retail voice or SMS roaming, would contribute to increased use of OTT services as a replacement, subject to the availability of low cost data connectivity. This effect may have been one of the drivers towards large volumes of bundled minutes and SMS. The increase in use of managed voice compared with OTT voice following the introduction of RLAH regulation seems to suggest that the reverse may also be true (see Figure 2-5). However, there is also evidence to suggest that there will be continued reliance on managed services for a portion of customers and/or types of communications (see Figure 2-7 and associated discussion), which could include users without smartphones or communications requiring any-to-any connectivity.

Source: WIK-Consult.

Although in the context of market analyses, European NRAs have generally not found OTT to be in the same relevant market as retail voice services, trends in volumes suggest that OTT may be substituting for at least a portion of communications that would otherwise be made via voice and SMS. OTT substitution is also considered to be responsible for significant revenue losses for telecom operators,[150] an effect which is likely to constrain their ability to raise prices for managed services without incurring further losses.

In the responses to the stakeholder survey, OTT messaging and voice were amongst the developments (along with eSIM) that were considered to be the greatest competitive challenge to traditional models of roaming provided by MNOs (see Figure 3-3). Respondents considered that additional traffic might migrate to OTT in the event that RLAH regulation was removed (see following figure).

Figure 3-6: Anticipated market share of OTT services in roamed mobile voice and messaging in the presence and absence of RLAH



Source: WIK-Consult based on stakeholder survey, n=20.

150 https://www.telecomasia.net/content/ott-substitution-cost-operators-104b-year.

Although it is not possible to project into the medium term with certainty, it seems reasonable to expect that OTT use will continue to expand, at the expense of traditional managed communications, especially for messaging, but also (abeit to a lesser extent) for voice.

Residual use of traditional managed communications is likely to remain for customers without smartphones and for communications requiring any-to-any connectivity. Developments such as RCS could also increase the attractiveness of managed communications compared with OTT (see Section 2.1.3). However, it seems likely that the retail pricing for voice and SMS – including when roaming - could be constrained by the availability of OTT alternatives. This constraint is however dependent on the availability of data roaming at attractive rates and of sufficient quality to support reliable delivery via OTT, and may as such be linked to the deployment of 5G eMBB (if this is associated with attractive flat-rate bundles).

The existence of such a constraint from OTT on retail voice and SMS roaming prices, might be sufficient to warrant the deregulation of retail voice and SMS roaming. However, it should be noted that such constraints may take some time to materialise, and therefore the potential for deregulation may be a question for a subsequent review, rather than the current review of the roaming regulations.

The effects on wholesale voice and SMS roaming are less clear. Competitive constraints from OTT on retail pricing for voice and SMS, might encourage operators to seek and agree reductions in wholesale roaming charges for these services, as wholesale charges are a significant input to the retail price. However, this incentive might not apply in negotiations which do not involve reciprocal access e.g. in the case of MVNOs.

3.4.2 Developments impacting competition in retail voice and SMS roaming

In Section 3.3.2.1 we discussed the potential role that eSIM could play in supporting competitive entry in data roaming for personal devices including handsets, tablets and laptops. When used in these devices, eSIM could also in theory facilitate the use of alternative roaming providers (via MVNO/As or through local break-out) for voice and SMS.

However, we expect that the impact on competition is likely to be limited. Firstly, as we noted in Section 3.3.2.1, take-up of eSIM on personal devices may be gradual and the uptake of alternative roaming offers is unclear. Secondly, and importantly, as illustrated in Section 2.3.1, MVNO/A which have entered the market as alternative roaming providers have started by offering data packages only, which is the set-up envisaged on

systems such as the eSIM-enabled iPhone.[151] This may be because use of an alternative provider for roaming calls and SMS would require the use of an additional number, which may not be known to the contacts of the recipient, and because eSIM, as currently implemented, does not support the use of multiple *simultaneous* profiles.

Another development that could impact competition in roaming calls and SMS markets is the move towards all-IP with the adoption of VoLTE and other services in the RCS suite. These developments could change the specification of and commercial models applied to existing services, and add new enhanced services, which require standardisation. The move to new technological solutions is likely to require new negotiations for roaming agreements, which may raise challenges for MVNO/As and smaller non-group operators which lack bargaining power. If they are unable to conclude roaming agreements on fair terms on the basis of modern IP technologies, this could impact their cost base and limit their ability to offer enhanced services to their customers while roaming. The degree to which this impacts their ability to compete, however depends on the take-up of RCS and weight given to such services by end-users, in light of the alternative OTT offers available.

3.5 Wholesale markets

We have noted a number of technological developments which could support entry and competition in retail roaming markets. Use of an eSIM-enabled alternative roaming provider for data in tandem with OTT for voice and messaging appears to be the most promising combination for roaming on handsets or other personal devices.

eSIM has already supported the development of competitive markets for cross-border data connectivity for IoT, with the involvement of MVNO/As and in some cases verticals such as car manufacturers.

However, as deploying mobile connectivity depends on access to spectrum, the entry and expansion of MVNO/As and verticals in retail markets is dependent on obtaining access to MNO networks in the visited country.

In this section we explore the scope of relevant wholesale markets and developments impacting competition in those markets.

151 Guidelines from Apple suggest that consumers wishing to use a secondary roaming provider should identify a “secondary” provider as their data provider, thereby retaining their original phone number.

3.5.1 Scope of wholesale markets

EU roaming regulations apply specifically to data, voice and SMS roaming on mobile networks, as a means of enabling cross-border communications to be provided to end-users.

However, it is worth noting that international roaming is one, but not the only means to achieve cross-border connectivity. MVNO agreements can also be used to support cross-border connectivity, and with the development of 5G and network slicing, access to network slices may become an important means to achieve this (especially where guaranteed QoS is required).

However, interviews conducted for this study suggest that while MVNO agreements are often preferred by specialist providers seeking to offer “global connectivity”, the availability of international roaming as a standardised form of access is considered necessary as a complement to MVNO to enable companies to address markets in which they have less traffic. International roaming is also used as a backstop in cases where specialist global connectivity providers have been unable to reach MVNO agreements, and more widely by smaller (non-group) MNOs whose business case primarily lies in their national market.

In this context it seems appropriate to continue to focus on roaming as a “lowest common denominator” safeguard ensuring the potential for cross-border connectivity. However, the precise interpretation of roaming may need to be revisited when models for roaming under 5G are fleshed out, and NRAs could also usefully monitor the degree to which MVNO access and access to network slices (in a 5G context) are offered in a competitive environment.

As regards the products to which roaming is applied, it seems likely that specific profiles will continue to be needed for data, voice and messaging. However, specific QoS profiles might be demanded for data, especially in the context of IoT. At the same time, as voice and messaging are increasingly be provided through IP technology (VoLTE and RCS), the detailed characteristics and commercial models associated with roaming for voice and messaging may evolve. If wholesale regulation of roaming is considered necessary for these services in the medium term, clear definitions will be needed of the characteristics of the roaming access to be provided and any rights or obligations applying to access to QoS guaranteed roaming.

3.5.2 Competitive developments affecting wholesale roaming markets

As noted above, developments such as eSIM show a degree of promise in facilitating competition in the roaming segment, and particularly in data, while OTT services offer the potential to apply pricing constraints on retail voice and SMS services. However,

MVNO/As, the main players that could take advantage of eSIM to provide alternative roaming offers to customers, are reliant on wholesale roaming access (at least to data) to enable them to provide these solutions. These players report in interviews that in the segment for personal communications, where their offers compete against those of MNOs, they are not always able to negotiate rates below the regulated cap. MNOs in countries with higher "roaming out" traffic volumes, which are unable to balance their roaming access requirements with complementary offers for access in countries with higher "roaming in" volumes, also report challenges in obtaining competitive rates, under the current bartering system for roaming agreements.

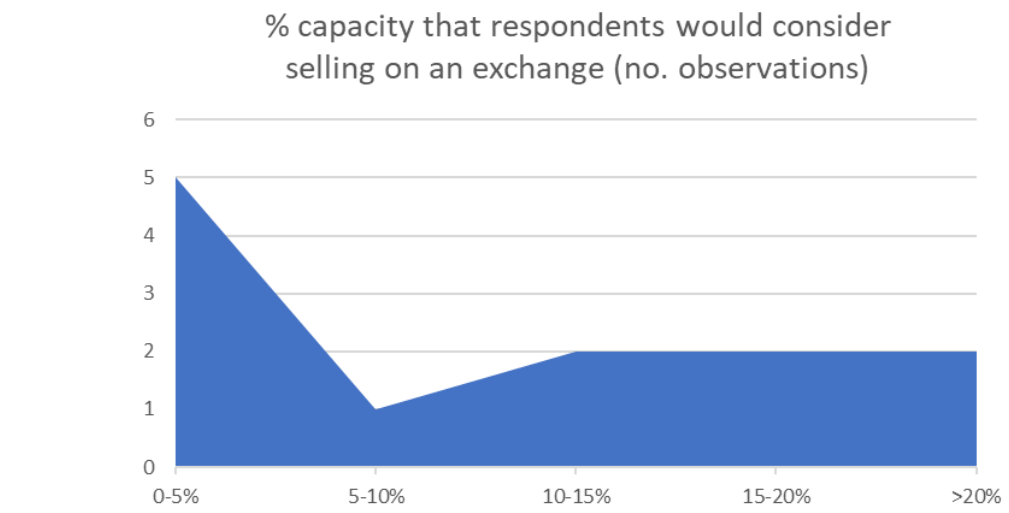
MVNO/As and verticals targeting the IoT/M2M segment are also heavily reliant on wholesale access including roaming to offer comprehensive geographic coverage. Interviews conducted for this study suggest that MVNOA/s appear to face fewer challenges in negotiating MVNO and roaming agreements for IoT/M2M than for handsets and personal devices because their traffic can be additive to that of their host. However, these players can face other challenges associated with wholesale access – notably a fragmented approach and barriers in some cases to permanent roaming, and potential difficulties in obtaining roaming with QoS differentiation on a consistent Europe-wide basis.

The source of imbalanced bargaining power between MVNO/As and non-group "roaming out" MNOs and larger MNO groups or MNOs in "roaming in" countries lies in high entry barriers to the provision of roaming access (due to the requirement to own spectrum in the country concerned) coupled with imbalances in their respective access requirements.

Proponents of wholesale capacity trading platforms, claim that, if certain conditions for participation are applied, including requirements for anonymous trading and the removal of the link between inbound and outbound roaming traffic, trading platforms could address the root-causes of market power in wholesale roaming (see Section 2.2.4 for discussion). The stakeholder survey confirms that some stakeholders would be interested in using this kind of platform,[152] with half of those responding saying they would consider trading more than 10% of their available capacity on such an exchange (see below).

152 A total of 24 respondents replied to the question on whether they would be willing to buy or sell roaming capacity on an exchange platform. 13 reported that they would buy capacity on such a platform with the remaining 11 saying that they would not be interested in buying from such a platform. Conversely, 11 stated that they would be willing to sell capacity on a platform, while 13 stated that they would not be willing to sell capacity. Of those willing to sell capacity via a trading platform, half stated that they would consider trading 10% or less of their available capacity, while the remaining respondents were prepared to consider trading a higher proportion of their capacity.

Figure 3-7: % capacity that respondents would consider selling on an exchange



Source: WIK-Consult based on stakeholder survey, n=12.

However, interviews confirm that larger mobile groups have limited interest in this arrangement, making countries in which most or all MNOs form part of such groups unlikely to benefit. Potentially for this reason, respondents were evenly split on whether they considered that the availability of a capacity trading platform would lower wholesale roaming prices to a competitive level. MVNO/As were particularly sceptical of the sufficiency of this model, and in most cases suggested that such a platform should not replace a wholesale price cap.

Evidence from electricity exchanges provides some support for capacity trading as a driver of liquidity and competition in generated electricity and transmission. However, the parallels with roaming traffic are not exact, and in several cases regulators have had to intervene to mandate or secure commitments for the electronic trading of given proportions or types of capacity, in order to ensure competitive outcomes. In all, it seems unlikely that the existence of wholesale capacity trading platforms for roaming (which is in any event nascent and unproven), would address bottlenecks in wholesale roaming, in the absence of regulatory intervention. The fact that in some countries, most or all MNOs may be unwilling participants poses further questions as regards its likely efficacy in those cases, even in the presence of regulatory requirements to trade.

As regards technological developments, as previously noted, 5G, VoLTE and RCS could impact the scope of data, voice and messaging wholesale markets. However, it is not clear that they will impact competitive dynamics in the market or the bargaining power between players, as these technological developments do not affect spectrum ownership or imbalances in traffic requirements for personal communications, which seem to be the main causes of competitive challenges.

3.6 Summary of relevant markets and competitive effects

Drawing on our analysis of technological and market developments, alongside interviews and responses to the online survey, we conclude that:

Data roaming

- At the retail level, there may be distinct markets for data roaming provided for handsets and personal devices versus data roaming provided for the purposes of IoT/M2M. It is likely that new segments will emerge for data offered at specific QoS (especially in the context of IoT/M2M). Wi-Fi hotspots may provide some competitive constraint, but this is not expected to be significant inter alia due to differences in coverage.
- Competition in retail data roaming for personal devices could be boosted by the new opportunities for alternative roaming providers (mainly MVNO/A) that have been provided by eSIM. However, the degree to which these services will constrain the data roaming prices of traditional MNOs is unclear. Moreover, MVNO/As are reliant on wholesale MVNO and roaming access (and perhaps in the future on the willingness of MNOs in the Visited Country to sell suitable 5G network slices) to provide competing offers.
- Retail data roaming for IoT/M2M is likely to be supplied in a competitive market. However, retail competition from MVNO/As and verticals is strongly dependent on wholesale access (MVNO access and in time 5G network slices, coupled with roaming)
- At the wholesale level, the nature of wholesale products could be affected by 5G and network slicing – with the addition of access to network slices (possibly with differentiated QoS) as an additional option, which could replace some MVNO and roaming agreements. However, conventional wholesale roaming is likely to be required as a complement to any MVNO or network slicing access. 5G is also likely to increase demand for QoS assured roaming offers
- Alternative roaming providers and non-group MNOs in “roaming-out” countries are likely to continue to be dependent on wholesale data roaming services in the medium term. Capacity trading platforms provide an interesting opportunity to support competition at the wholesale level (and the diversity of offers). However they will likely be ineffective at promoting competition in markets where most or all of the existing MNOs form part of larger groups, which already have alternative arrangements. Thus bottlenecks (at least in these cases) are likely to persist.
- There appear to be fewer competitive challenges to negotiating wholesale access for data for IoT/M2M purposes than for personal devices. However, there may be barriers to permanent roaming in some cases or challenges in obtaining

access with appropriate QoS characteristics. Where challenges in obtaining appropriate access persist, given the cross-border nature of many M2M/IoT services (which may be mobile services such as connected cars, or services provided to facilities across multiple countries), they could have a detrimental impact on the single market.

Voice and SMS roaming

- Whereas voice and SMS are treated as distinct markets today, distinctions may become more blurred with the move to Rich Communications Services and offers may expand to include video calls and other features. There is however likely to be continued demand for basic voice communications.
- It cannot be excluded that OTT might form part of the relevant retail market for voice and messaging services in the future. In any event, OTT is likely to provide a continued retail pricing constraint on charges for managed voice and especially SMS communications. However, this potential development depends on data roaming or alternatives such as Wi-Fi being available on a cost-effective basis. Notwithstanding any potential substitution between OTT and managed services, there is likely to be residual use of traditional managed telecom services for those not owning smartphones or for services requiring interconnectivity.
- Given availability of cost-effective data roaming, competitive prices for retail voice and SMS may be supported by the availability of OTT services, and potentially (but to a much lesser extent) competition via alternative roaming offers supported by eSIM.
- The move to all-IP with VoLTE and RCS roaming is likely to require a recalibration of the nature of wholesale offers and associated commercial terms. However, this is unlikely to affect existing competitive dynamics in the market.
- Pressure on retail prices for managed voice and SMS (and their successors) could constrain negotiated wholesale prices, as the wholesale price forms an important input to the retail price. This constraint is less likely to be present when MNOs negotiate wholesale tariffs with MVNO/As. However, the impacts may be less significant if MVNO/As focus on data roaming and facilitating OTT offers.

The tables overleaf provide a summary of our findings for the implications of technological and market developments on competition in roaming markets respectively for personal devices and for IoT/M2M.

Table 3-6: Summary of conclusions concerning the implications of technological and market developments on competition in roaming markets in the medium term

Personal devices	Data roaming		Voice roaming		SMS roaming		Dependencies
	Retail	Wholesale	Retail	Wholesale	Retail	Wholesale	
Wi-Fi hotspots	+	+	(+) via OTT		(+) via OTT		
eSIM	+(+)		(+)		(+)		Take-up, wholesale access or roaming
5G/network slicing		+/-					Take-up
OTT voice and SMS			++	+	+++	++	Reliable low cost data connection
Capacity trading exchanges		(+)		(+)		(+)	Participation of multiple MNOs per country

+ indicates increase in competition, (+) minor or uncertain increase, - indicates potential competitive challenge

IoT	Data roaming	
	Retail	Wholesale
Wi-Fi hotspots	(+)	(+)
eSIM	+++	
5G/network slicing		++/-

Source: WIK-Consult.

3.7 Implications for regulation

In the context of this study, we identified a number of technological developments which were likely to have implications for competition in the provision of cross-border connectivity in coming years. These included eSIM, OTT and 5G and associated network slicing.

However, the impact of eSIM, especially in the consumer segment, is likely to take some years to materialise, and it may, at least initially, only be available in high-end devices.

Meanwhile, the potential for OTT to fully substitute for managed voice and messaging is growing over time, but is dependent on the continued availability of attractive commercial offers for data while roaming. This implies that OTT would not be an effective substitute for roaming voice if regulation of roaming for data were lifted.

The migration to 5G has implications for devices that roam (IoT), and possibly for wholesale arrangements among network operators, but does not appear likely to require a regulatory response in regard to roaming over the next few years.

In this concluding chapter, we therefore distinguish between issues which are present today, and for which action seems likely to be needed under the current review, on the basis of our research, and potential developments within a 5-10 year window, which are more relevant for consideration in a subsequent review of roaming regulations.

3.7.1 Issues for immediate attention

There does not seem to be a case for significant changes to the regulatory rules applying to international roaming under the current review (without prejudice to review of maximum wholesale rates). There are nonetheless a number of issues which our analysis suggests could benefit from more immediate attention.

One issue that was raised by MVNO/As interviewed for this study is that differing rules in different countries or different approaches by operators to permanent roaming could affect the potential to deploy IoT services.[153]

In this context, it should be noted that permanent roaming is not prohibited under the roaming regulations and is frequently offered on commercial terms for IOT/M2M purposes (see case studies concerning MVNO/As). However, there is scope in the roaming regulations for MNOs to include conditions in their Reference Offers which are designed to "prevent permanent roaming or anomalous or abusive behaviour".

If these provisions are used in a manner which prevents effective roaming access for the purposes of ensuring connectivity for connected things, it could impact the single market by creating problems for the cross-border connectivity of connected things which are by their nature mobile. It could also restrict the potential for an operator to provide pan-European connectivity for connected objects (whether or not mobile) that may be manufactured in one country, but distributed and installed in different locations across the EU.

It could thus be helpful to assess whether there is a need for more explicit rules or guidelines governing access requests for permanent roaming for the purposes of connectivity for M2M/IoT. In order to avoid unintended use of permanent roaming for personal communications[154] as well as addressing concerns of IoT connectivity providers,[155] it might also be helpful to provide guidance on how M2M should be

153 One case that was highlighted to illustrate challenges in obtaining roaming in the context of IoT was the dispute between Transatel and Telefonica Deutschland that was referred to the German regulator BNetzA. https://www.transatel.com/in-the-press/transatel-wins-german-regulatory-decision-on-access-to-telefonica-data-roaming/.

154 The potential use of eSIM to enable multiple contracts for mobile "roaming" connectivity with different identifiers could in theory make it harder to identify users which are in practice permanently roaming.

155 Interviewees noted that there could be a lack of clarity about whether a roaming application was "M2M" or involved personal interaction, especially in cases – such as connected cars – where different applications may be provided by the same global connectivity provider under the same contract for different purposes in parallel (e.g. telemetry and in-car entertainment).

distinguished from personal communications,[156] and to assess what action could reasonably and proportionately be taken by MNOs to enforce conditions they may apply for the use of permanent roaming.

Finally, our research highlights the important role that standards can play in fostering innovation and competition in global connectivity markets. There could thus be a role for the EU to observe and if necessary support the development of standards that could allow QoS-guaranteed roaming for M2M applications requiring it, as well as closely following the implementation of standards adopted for eSIM in order to ensure that they evolve in such a way as to facilitate selecting and switching between multiple profiles.

3.7.2 Issues for a subsequent review

Looking into subsequent reviews, our findings about potential constraints from OTT services suggest that there may be scope in the medium term to lift retail roaming obligations (RLAH) on voice and SMS offers.

However, due to the reliance of OTT on data connections, continued retail RLAH obligations for roaming data may be needed, unless there is evidence that competition from alternative roaming provision via eSIM (or the strong development – contrary to expectations - of local break-out) can effectively constrain retail data roaming prices. Such evidence might take the form of significant take-up of alternative roaming services or LBO by EU customers for travel outside the EU, leading to significant reductions in data roaming offers for such customers. It will not in any event be possible to gauge the effectiveness of alternative roaming offers until there is higher take-up of eSIM enabled smartphones.

At the wholesale level, it seems likely that data roaming regulation will continue to be required in the medium term both to support roaming for personal communications and to provide a back-stop to support roaming for the growing IoT/M2M communications market. It is also possible that bottlenecks might emerge in the future with regard to wholesale provision of roaming services that provide assured QoS e.g. for M2M services. If this results in an impediment to service innovation and competition across the single market, then it might become appropriate at that time to foster and/or recognise relevant standards and consider obligations which would ensure the pan-European provision of QoS assured roaming services.

If competition challenges persist in wholesale data roaming (in its basic form and/or with QoS guarantees), there is a further question as to which kind of obligation would be most appropriate to address them.

156 Any such guidance may however fall beyond the scope of the Roaming Regulation and may thus need to be addressed separately.

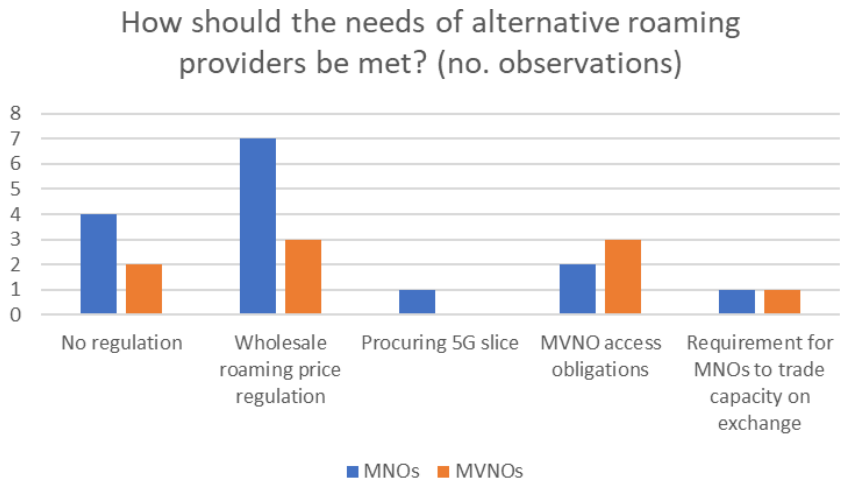
Due to the history of roaming regulation, European operators are familiar with the current system of obligations to provide roaming at regulated prices, and respondents to the online survey conducted for this study suggested that wholesale price obligations would be the most appropriate solution to address the needs of alternative roaming providers (see Figure 3-8).

However, other solutions might be relevant as an alternative (in certain circumstances) to roaming access or as a facilitator of competition in wholesale roaming markets.

For example, MVNO/As providers responding to the survey cited MVNO access as of equal importance to roaming for their business. In the future, network slicing arrangements under 5G may play a role in supporting QoS guaranteed roaming for IoT applications (see Section 2.2.3.2). Proponents of capacity trading platforms have also claimed that this mechanism could foster competition in wholesale roaming markets, as well as facilitating the development and trading of more variants of wholesale roaming, such as QoS guaranteed options. However, as discussed in Section 2.2.4, anonymised capacity trading as an alternative to regulated wholesale roaming charges, is unlikely to be widely adopted without a requirement for operators to trade a given proportion of capacity, and even then, it is unclear whether it would address pricing concerns,

Most stakeholders responding to the survey did not call for obligations to be applied on access to 5G network slices or for requirements for MNOs to make access available via a capacity trading exchange. This may be because these options are less relevant or desirable, or it could be due to the fact that they are less well developed, and therefore their significance is less well understood. As there are likely to be further insights into these developments in the coming years as 5G is deployed and commercial capacity trading platforms are launched, it may be helpful to analyse whether there is a need for any measures in these areas in a subsequent review of the roaming regulations.

Figure 3-8: How should the needs of alternative roaming providers be met – responses from MNOs and MVNOs



Source: WIK-Consult based on stakeholder survey, n=26.

It is less clear what intervention, if any, will be needed at the wholesale level going forward concerning voice and SMS. If, on the basis of competition from OTT, retail markets are found to be prospectively competitive in the presence of data roaming regulation, this could warrant the deregulation of wholesale markets as well as the removal of RLAH (retail) obligations under a future review of the roaming regulations. However, it is possible that some challenges could persist for non-attached mobile operators and MVNO/As, including with the migration to IP-based voice by means of VoLTE and/or RCS, and with the associated development of new wholesale offers. A future review of the roaming regulations should consider how to deal with this issue, in light of experience in the negotiation of wholesale roaming agreements for IP-based voice and messaging.

Annex I: Interviews

The following companies and individuals were interviewed in the preparation of the interim report. The companies were selected so as to be representative of the interests amongst telecommunication operators and service providers, equipment manufacturers and application providers.

- GSMA
- Telefonica
- Hutchison
- Play
- Transatel
- Ericsson
- Microsoft
- Google
- Facebook
- Tony Shortall
- Tritex
- Cubic Telecom
- Truphone
- Gemalto

Interviewees were sent a list of questions beforehand, asking for information and their opinions about the following topics:

- Their involvement in the supply of mobile roaming and/or global connectivity services and/or communication services provided on a cross-border basis
- Their expectations about the involvement of others in the supply chain
- Their expectations about roaming traffic trends and the balance between personal communications and IoT
- Their views on the likely impact on mobile competition in the medium term of Wi-Fi offload, OTT services, eSIM, RCS and 5G/network slicing.
- Their views on the continued need for wholesale regulation in mobile roaming markets, and potential demand for and efficacy of a wholesale capacity trading platform as an alternative

The comments of interviewees were noted and verified with those participating.

Annex II: Stakeholder survey questions

Online stakeholder survey accompanying the study for the European Commission (SMART 2018/0012)

WIK-Consult is conducting a study for the European Commission on "Technological developments and roaming". The study aims to assess technological and other market developments which could impact competition in wholesale and/or retail roaming markets over the medium term (5-10 years), with a view to understanding whether regulation of data, voice and SMS roaming will continue to be relevant.

In this context, we are seeking the views of stakeholders across the value chain about developments in markets for roaming and cross-border connectivity and the potential effects on competition. Such developments include the evolution of eSIM and 5G as well as the role played by existing services such as Wifi and OTT voice and messaging services in providing an alternative to traditional roaming.

We need you to provide your company name in order to track the response rate amongst relevant stakeholder groups and ensure that a representative range of views have been included. We will not identify specific respondents to the survey in our report, but will rather use the survey results to show the aggregate view of different types of stakeholder (to the extent there are any patterns in the response). We may quote comments received in an anonymous manner. If we intend to cite you or your company, we will contact you to request your consent. The results of the study will feed in to the European Commission's ongoing review of roaming regulations. We look forward to receiving your response by 13 March 2019.

Section A: Background

A1. Please enter your company name:

A2. Which best describes your primary field of business in relation to mobile roaming/global connectivity?

- ☐ mobile network operator
- ☐ MVNO/A
- ☐ equipment manufacturer
- ☐ operating system developer
- ☐ application provider
- ☐ vertical industry (e.g. car manufacturer)
- ☐ consultant/expert
- ☐ other

A3. In which country or countries do you have mobile operations or supply communication services, if relevant?

- ☐ Europe-wide
- ☐ Albania
- ☐ Andorra
- ☐ Austria
- ☐ Belarus
- ☐ Belgium
- ☐ Bosnia and Herzegovina
- ☐ Bulgaria
- ☐ Croatia
- ☐ Czech Republic
- ☐ Denmark
- ☐ Estonia
- ☐ Finland
- ☐ France
- ☐ Germany
- ☐ Greece
- ☐ Hungary
- ☐ Iceland
- ☐ Ireland

- [ ] Italy
- [ ] Latvia
- [ ] Liechtenstein
- [ ] Lithuania
- [ ] Luxembourg
- [ ] Malta
- [ ] Moldova
- [ ] Monaco
- [ ] Netherlands
- [ ] Norway
- [ ] Poland
- [ ] Portugal
- [ ] Romania
- [ ] Russia
- [ ] San Marino
- [ ] Serbia and Montenegro
- [ ] Slovakia
- [ ] Slovenia
- [ ] Spain
- [ ] Sweden
- [ ] Switzerland
- [ ] Ukraine
- [ ] United Kingdom
- [ ] USA
- [ ] Other Region

A4. How many employees does your business have?

- ☐
- 10 - 250 ☐
- 250 - 1.000 ☐
- 1.000 - 10.000 ☐
- > 10.000 ☐

Section B: Technological developments

For each of the following technological and business developments, which are likely to present the greatest competitive challenge to traditional retail roaming provision by MNOs over a 5-10 year horizon? Rank each from 1 (limited challenge) to 10 (significant challenge). Please indicate the expected effect separately for (a) handsets; (b) other personal devices including tablets, laptops and wearables; and (c) the Internet of things e.g. in the form of telemetry for connected cars.

B1. Wifi in the home, work or hotels

Mobile handsets ☐☐

Other personal devices including tablets, laptops and wearables ☐☐

IoT/M2M ☐☐

B2. Public Wifi hotspots outside hotels, place of work

Mobile handsets ☐☐

Other personal devices including tablets, laptops and wearables ☐☐

IoT/M2M ☐☐

B3. Over-the-top (OTT) voice services

Mobile handsets ☐☐

Other personal devices including tablets, laptops and wearables ☐☐

IoT/M2M ☐☐

B4. Over-the-top (OTT messaging services

Mobile handsets ☐☐

Other personal devices including tablets, laptops and wearables ☐☐

IoT/M2M ☐☐

B5. eSIM

Mobile handsets ☐☐

Other personal devices including tablets, laptops and wearables ☐☐

IoT/M2M ☐☐

B6. 5G and network slicing

Mobile handsets

Other personal devices including tablets, laptops and wearables

IoT/M2M

B7. Please explain

Section C: Significant actors in the provision of roaming/global connectivity

Which players do you expect to play a significant role in providing roaming/global connectivity services in the medium term? List from 1 (no role) to 10 (significant role). Please indicate the expected involvement separately for (a) handsets; (b) other personal devices including tablets, laptops and wearables; and (c) the Internet of things e.g. in the form of telemetry for connected cars.

C1. Mobile network operators

Mobile handsets

Other personal devices including tablets, laptops and wearables

IoT/M2M

C2. MVNO/As

Mobile handsets

Other personal devices including tablets, laptops and wearables

IoT/M2M

C3. Specialist Wifi aggregators

Mobile handsets

Other personal devices including tablets, laptops and wearables

IoT/M2M

C4. Equipment manufacturers

Mobile handsets

Other personal devices including tablets, laptops and wearables

IoT/M2M

C5. Applications providers

Mobile handsets

Other personal devices including tablets, laptops and wearables

IoT/M2M

C6. Operating system developers

Mobile handsets

Other personal devices including tablets, laptops and wearables

IoT/M2M

C7. Vertical industries e.g. car manufacturers

Mobile handsets

Other personal devices including tablets, laptops and wearables

IoT/M2M

C8. Other

Mobile handsets

Other personal devices including tablets, laptops and wearables

IoT/M2M

C9. Please explain

Section D: Impact of alternative roaming providers

What market share do you expect that providers other than traditional mobile network operators (e.g. MVNO/As, verticals, device manufacturers) might have on the provision of roamed/cross-border data within the EU in a 5-10 year period, in the event that retail roaming regulated was removed? Please indicate the expected shares [in expected total percentages] separately for (a) handsets; (b) other personal devices including tablets, laptops and wearables; and (c) the Internet of things e.g. in the form of telemetry for connected cars.

D1. MVNO/As

The numerical values are to be interpreted as percentages.

Example: "I expect MVNO/As to have 20% of the market share for cross-border connectivity/roaming on mobile handsets within a 5-10 year period"

Mobile handsets

Other personal devices including tablets, laptops and wearables

IoT/M2M

D2. Verticals such as car manufacurers

The numerical values are to be interpreted as percentages.

Example: "I expect MVNO/As to have 20% of the market share for cross-border connectivity/roaming on mobile handsets within a 5-10 year period"

Mobile handsets	
Other personal devices including tablets, laptops and wearables	
IoT/M2M	

D3. Device manufacturers

The numerical values are to be interpreted as percentages.

Example: "I expect MVNO/As to have 20% of the market share for cross-border connectivity/roaming on mobile handsets within a 5-10 year period"

Mobile handsets	
Other personal devices including tablets, laptops and wearables	
IoT/M2M	

D4. Other

The numerical values are to be interpreted as percentages.

Example: "I expect MVNO/As to have 20% of the market share for cross-border connectivity/roaming on mobile handsets within a 5-10 year period"

Mobile handsets	
Other personal devices including tablets, laptops and wearables	
IoT/M2M	

D5. Please explain the basis for your estimates including e.g. the degree to which they draw on assumptions around eSIM and/or developments in connection with 5G/network slicing and the development of connectivity for IoT.

D6. Would competition from alternative global connectivity providers constrain the ability of mobile network operators to charge higher prices in the event that roaming regulation were removed? Please specify separately for (i) data voice and SMS on handsets, (ii) data on personal devices; and (iii) data for IOT. Please list from 1 (no constraint) to 10 (significant constraint)

Data, voice and SMS on mobile handsets ☐

Data on other personal devices including tablets, laptops and wearables ☐

Data for IoT/M2M ☐

Section E: Effect of wifi hotspots

E1. Status quo - with roam like at home regulation

What share do you expect that providers or aggregators of Wifi hotspots might have of roamed data volumes on handsets and personal mobile-connected devices in the EU within a 5-10 year timeframe? Please consider only connectivity provided outside hotels, airports, workplaces. Please provide answers (a) under the status quo in the presence of retail roaming regulation (roam like at home); and (b) in the event that retail roaming regulation were removed

0 - 5% ☐ 5 - 20% ☐ 20 - 40% ☐ 40 - 60% ☐ 60 - 80% ☐ 80 - 100% ☐

E2. In the absence of retail roaming regulation

What share do you expect that providers or aggregators of Wifi hotspots might have of roamed data volumes on handsets and personal mobile-connected devices in the EU within a 5-10 year timeframe? Please consider only connectivity provided outside hotels, airports, workplaces. Please provide answers (a) under the status quo in the presence of retail roaming regulation (roam like at home); and (b) in the event that retail roaming regulation were removed

0 - 5% ☐ 5 - 20% ☐ 20 - 40% ☐ 40 - 60% ☐ 60 - 80% ☐ 80 - 100% ☐

E3. To what extent do you expect that competition from Wifi hotspots/aggregation outside hotels, airports etc would constrain the ability of MNOs to price mobile data roaming above the competitive level in the absence of retail regulation on mobile data roaming? List from 1 (no constraint) to 10 (significant constraint)

Status quo - with roam like at home regulation ☐

In the absence of retail roaming regulation ☐

E4. Please explain

Section F: Effect of OTT services

F1. Status quo - with roam like at home regulation

What share do you expect that OTT providers such as Skype, Whatsapp and Viber of online voice and messaging services might have of the minutes of calls and numbers of messages sent via mobile devices within a 5 year period? Please indicate separately the market shares you expect (a) under the status quo with Roam Like at Home regulation; and (b) and in the event that retail regulation on voice and messaging were removed.

0 - 5% | 5 - 20% | 20 - 40% | 40 - 60% | 60 - 80% | 80 - 100%

☐ ..... ☐ ..... ☐ ..... ☐ ..... ☐ ..... ☐

F2. In the absence of retail roaming regulation

What share do you expect that OTT providers such as Skype, Whatsapp and Viber of online voice and messaging services might have of the minutes of calls and numbers of messages sent via mobile devices within a 5 year period? Please indicate separately the market shares you expect (a) under the status quo with Roam Like at Home regulation; and (b) and in the event that retail regulation on voice and messaging were removed.

0 - 5% | 5 - 20% | 20 - 40% | 40 - 60% | 60 - 80% | 80 - 100%

☐ ..... ☐ ..... ☐ ..... ☐ ..... ☐ ..... ☐

F3. Status quo - with roam like at home regulation

In your view, within a 5 to 10 year period, will OTT services provide a substitute for managed voice and SMS, or complement them?

Substitute | Complement

☐ ..... ☐

F4. In the absence of retail roaming regulation

In your view, within a 5 to 10 year period, will OTT services provide a substitute for managed voice and SMS, or complement them?

Substitute | Complement

☐ ..... ☐

F5. **Would OTT services provided by application providers constrain the ability of mobile network operators to charge higher prices for voice and SMS services, in the absence of retail roaming regulation? List from 1 (no constraint) to 10 (significant constraint)**

Status quo - with roam like at home regulation ☐

In the absence of retail roaming regulation ☐

F6. **Please explain**

Section G: Mobile capacity trading platforms

G1. **If an exchange to trade mobile capacity were established, would your firm use it to (a) sell capacity; (b) buy capacity?**

Buy ☐

Sell ☐

G2. **If you would consider selling capacity on such an exchange, what proportion of your available data capacity would you consider trading?**

0 - 5% ☐

5 - 10% ☐

10 - 15% ☐

15 - 20% ☐

> 20% ☐

G3. **Do you consider that, in the absence of wholesale regulation, a capacity trading platform would lower wholesale roaming prices to a competitive level?**

Yes ☐

No ☐

G4. Please explain

Section H: Reliance on wholesale regulation

H1. What degree of reliance will alternative providers of roaming/global connectivity have on regulated wholesale products (roaming and/or regulated MVNO access) to offer (i) data voice and SMS on handsets, (ii) data on personal devices; and (iii) data for IOT?

	High	some	limited	none
Data, voice and SMS on mobile handsets	☐	☐	☐	☐
Data on other personal devices including tablets, laptops and wearables	☐	☐	☐	☐
Data for IoT/M2M	☐	☐	☐	☐

H2. How can/should the needs of these players be met, if at all?

No regulation ☐

wholesale roaming price regulation ☐

procuring a slice of a 5G network ☐

MVNO access obligations ☐

Requirement for MNOs to trade capacity on an exchange ☐

H3. Please explain

Section I: Relevance of roaming regulation

Based on your expectations about how the market would develop in the absence of regulation, how likely do you think it is that (i) voice roaming; (ii) SMS roaming; and (iii) data roaming could be deregulated at (i) retail level; and/or at (ii) wholesale level in a 5-10 year timeframe? Please rank from 1 (unlikely) to 10 (very likely).

I1. Retail level

Voice roaming ☐☐

SMS roaming

Data roaming

I2. Wholesale level

Voice roaming

SMS roaming

Data roaming

Thank you for your response. Please contact Ilsa Godlovitch on i.godlovitch@wik.org if you have any questions about the study or j.lennartz@wik.org if you have questions about the administration of the survey.

References

Arnold, René, Christian Hildebrandt, Peter Kroon, & Serpil Taş. 2017. The Economic and Societal Value of Rich Interaction Applications (RIAs). Bad Honnef: WIK-Consult.

Arnold, René & Serpil Taş. Auswirkungen von OTT-1-Diensten auf das Kommunikationsverhalten – eine nachfrageseitige Betrachtung. WIK-Diskussionsbeitrag Nr. 440. Bad Honnef: WIK.

Arnold, René, & Anna Schneider (2017). The Functionalities of Success: A Psychological Exploration of Mobile Messenger Apps Success. TPRC45, Arlington, VA, 8.-9. September, 2017.

Arnold, René, & Anna Schneider (2018). Oops, I texted again. Bad Honnef, Cologne: WIK and Fresenius University of Applied Sciences.

Arnold, René, Anna Schneider, & Christian Hildebrandt (2016). All Communications Services Are Not Created Equal – Substitution of OTT Communications Services for ECS from a Consumer Perspective. TPRC44, Arlington, VA, 30. September - 01. October, 2016.

BEREC. 2016. International Roaming BEREC Benchmark Data Report April - September 2015 BoR(16)28.

BEREC. 2016. BEREC Guidelines on the Implementation by National Regulators of European Net Neutrality Rules, BoR (16) 127.

BEREC. 2018. International Roaming BEREC Benchmark Data Report October 2017 - March 2018 BoR (18)160.

Brubaker, Jed R., Gina Venolia, & John C. Tang. 2012. Focusing on Shared Experiences: Moving beyond the Camera in Video Communication. Designing Interactive Systems Conference, Newcastle Upon Tyne, 11.-15. June, 2012.

Church, Karen, & Rodrigo de Oliveira. 2013. What's Up with WhatsApp?: Comparing Mobile Instant Messaging Behaviors with Traditional SMS. 15th International Conference on Human-Computer Interaction with Mobile Devices and Services, Munich, 30. August 2013.

Cisco. 2018. Cisco Visual Networking Index (VNI).

Dominguez, Javier. 2011. Competing for Partners: Strategic Games in International Wholesale Roaming (October 27, 2011).

European Commission. 2016. COMMISSION STAFF WORKING DOCUMENT Accompanying the document “Report from the Commission to the European Parliament and the Council on the review of the wholesale roaming market” {COM(2016) 398 final} Brussels, 15.6.2016 SWD(2016) 200 final https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2016:0200:FIN:EN:PDF.

Gemalto. 2017. Gemalto and Microsoft join forces to provide seamless connectivity for Windows 10 devices, press release, 21 February 2017, http://www.gemalto.com/press/Pages/Gemalto-and-Microsoft-join-forces-to-provide-seamless-connectivity-for-Windows-10-devices.aspx.

3GPP. 2019. Technical Specification Group Services and System Aspects; Release 15 Description; Summary of Rel-15 Work Items (Release 15), TR 21.915 V1.0.0 (2019-03).

Gries, Christin, & Christian Wernick. 2017. Bedeutung der embedded SIM (eSIM) für Wettbewerb und Verbraucher im Mobilfunkmarkt. WIK-Diskussionsbeitrag Nr. 422. Bad Honnef: WIK.

Grzybowski, Lukasz; Liang, Julienne; Zulehner, Christine (2017): Bundling, consumer retention and entry: evidence from fixed broadband market. 14th International Telecommunications Society (ITS) Asia-Pacific Regional Conference: "Mapping ICT into Transformation for the Next Information Society", Kyoto, Japan, 24-27June, 2017, https://www.econstor.eu/bitstream/10419/168483/1/Grzybowski-Liangy-Zulehner.pdf.

GSMA. 2014. Benefits Analysis of GSMA Embedded SIM Specification on the Mobile Enabled M2M Industry, https://www.gsma.com/iot/wp-content/uploads/2014/10/Benefits-Analysis-GSMA-Embedded-SIM-Specification.pdf.

GSMA. 2015. RSP Technical Specification Version 2.0 14 October 2016, https://www.gsma.com/newsroom/wp-content/uploads/SGP.22_v2.0.pdf.

GSMA. 2016. Emerging Trends & Market Predictions, https://www.gsma.com/iot/wp-content/uploads/2016/09/Connected-car-emerging-trends-and-market-predictions.pdf.

GSMA. 2017. Messaging as a Platform - The Operator Opportunity.

GSMA. 2017. RSP Architecture V2.2, 01 September 2017, https://www.gsma.com/newsroom/wp-content/uploads//SGP.21_v2.2.pdf.

GSMA. 2017: The future of the SIM: potential market and technology implications for the mobile ecosystem, February 2017 https://www.gsmaintelligence.com/research/?file=3f8f4057fdd7832b0b923cb051cb6e2c&download.

GSMA. 2018. eSIM Whitepaper - The what and how of Remote SIM Provisioning, March 2018, https://www.gsma.com/esim/wp-content/uploads/2018/06/eSIM-Whitepaper-v4.11.pdf.

GSMA. 2018. IMS Roaming, Iterconnection and Interworking Guidelins, Version 28.0, 02 May 2018, https://www.gsma.com/newsroom/wp-content/uploads//IR.65-v28.0.pdf.

GSMA. 2018. RCS Universal Profile Service Definition Document - Version 2.3.

GSMA. 2018. The mobile economy.

GWI. 2019. „Online Activities in the Last Month" - Used a chat or instant messaging service / app.

Hetting, C. 2013. Seamless Wi-Fi offload: a business opportunity today.

Husnjak, Perakovic and Forenbacher (2018) Data Traffic Offload from Mobile to Wi-Fi networks: behavioural patterns of smartphone users.

IMDA. 2018. Consultation Paper issued by IMDA, 6 June 2018, https://www.imda.gov.sg/-/media/imda/files/inner/pcdg/consultations/consultation-paper/public-consultation-on-embedded-sim-technology/consultation-document-for-esim.pdf?la=en.

Infante Jorge, & Ivan Vallejo. 2012. Regulation of international roaming in the European Union—Lessons learned, Telecommunications Policy Volume 36, Issue 9.

Informa. 2013. Next Generation Roaming: Service Evolution and Innovation - Opportunities and challenges for operators amid technical and regulatory change https://www.gsma.com/futurenetworks/wp-content/uploads/2013/11/Tata-Next-Gen-Roaming_v4.pdf.

ITU-R. 2015. Report ITU-R P.2346-0 (05/2015): Compilation of measurement data relating to building entry loss.

Kroon, Peter, & René Arnold. 2018. Die Bedeutung von Interoperabilität in der digitalen Welt: Neue Herausforderungen in der interpersonellen Kommunikation - WIK-Diskussionsbeitrag Nr. 437. Bad Honnef: WIK.

Marcus, J. Scott, & Gabor Molnar. 2017. Network Sharing and 5G in Europe: The Potential Benefits of Using SDN or NFV, presented at ITS Europe in Passau, at https://papers.ssrn.com/sol3/Delivery.cfm/SSRN_ID3007398_code333755.pdf?abstractid=3007398&mirid=1.

Marcus, J. Scott, & Imme Philbeck. 2010. Study on the options for addressing competition problems in the EU roaming market - SMART 2010/0018, http://ec.europa.eu/information_society/activities/roaming/regulation/consult2011/index_en.htm

Marcus, J. Scott, Christin Gries, Christian Wernick, & Imme Philbeck. 2016. Entwicklungen im internationalen Mobile Roaming unter besonderer Berücksichtigung struktureller Lösungen. WIK-Diskussionsbeitrag Nr. 403. Bad Honnef: WIK.

OECD. 2015. Triple and Quadruple Play Bundles of Communication Services, OECD Science, Technology and Industry Policy Papers, No. 23, OECD Publishing, Paris, https://www.oecd-ilibrary.org/docserver/5js04dp2q1jc-en.pdf?expires=1560420143&id=id&accname=guest&checksum=188D1E5053B5B193923E1101A98E04E2

O'Hara, Kenton, Alison Black, & Matthew Lipson. 2006. Everyday practices with mobile video telephony. Conference on Human Factors in Computing Systems, Montréal, 22.-27. April, 2006.

O'Hara, Kenton, Michael Massimi, Richard Harper, Simon Rubens, & Jessica Morris. 2014. Everyday dwelling with WhatsApp. 17th Conference on Computer Supported Cooperative Work & Social Computing, Baltimore, MD, 15.-19. February, 2014.

OpenSignal. 2018. The State of Wi-Fi vs Mobile Network Experience as 5G arrives. OpenSignal November 2018 https://opensignal.com/reports-data/global/data-2018-11/state_of_wifi_vs_mobile_OpenSignal_201811.pdf.

Research and Markets. 2018. $978 Million eSIM Market by Application, Vertical, and Geography - Global Forecast to 2023, 3 April 2018, https://www.prnewswire.com/news-releases/978-million-esim-market-by-application-vertical-and-geography---global-forecast-to-2023-300623446.html.

ROCCO. 2018. eSIM for the Roaming Consumer - Strategy Report 2018, http://marketing.uros.com/ROCCO%20Roaming%20Consumer%20eSIM%20Strategy%20Report%202018.pdf.

Sauter, Marc, & Andreas Sebayang. 2017. Windows 10 on ARM soll Intels x86-Ultrabooks übertreffen, 1 June 2017, https://www.golem.de/news/always-connected-pc-windows-10-on-arm-soll-intels-x86-ultrabooks-uebertreffen-1705-128108.html.

Shatlin, Ilja. 2016. What are virtual SIM cards and what do they do? March 16, 2016, Kapserky blog: https://www.kaspersky.com/blog/virtual-sim/11572/.

Shortall Tony. 2010. Roaming in Europe and the United States, Utility Law Review 18(1).

Spanjaard, Thierry. 2018. Consumer eSIm not likely to happen soon!, 1 May 2018, in: Smart Insights, https://www.smartinsights.net/single-post/2018/05/07/Consumer-eSIM-not-likely-to-happen-soon.

Startup Lithuania. 2015. Lithuanian Startup Widerfi Enters the World's largest accelerator, 27 May 2015, https://www.startuplithuania.com/news/lithuanian-startup-widerfi-enters-the-worlds-largest-accelerator/.

Tenbrock, Sebastian & René Arnold. 2016. Die Bedeutung von Telekommunikation in intelligent vernetzten PKW. WIK Diskussionsbeitrag Nr. 413. Bad Honnef: WIK.

Treves, Micky. 2018. Building and leveraging the next generation of Connected Devices, https://query.prod.cms.rt.microsoft.com/cms/api/am/binary/RE2IO4V.

Tsurusawa, Munefumi. 2017. Latest Trends in Remote SIM Provisioning Technology, in: New Breeze, Summer 2017, https://www.ituaj.jp/wp-content/uploads/2017/08/nb29-3_web-01-SpecialRemoteSIM.pdf.

Wernick, Christian, & Christin Gries. 2017. Economic aspects of embedded SIM for the telecommunications consumer segment, 28th European Regional Conference of the International Telecommunications Society (ITS): Competition and Regulation in the Information Age, Passau, Germany, July 30 - August 2, 2017, International Telecommunications Society (ITS), Passau, https://www.econstor.eu/bitstream/10419/169504/1/Wernick-Gries.pdf.

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