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THE IMPACT OF NETWORK SHARING ON COMPETITION: THE CHALLENGES POSED BY EARLY VERSUS MATURE 5G

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ABSTRACT

The rollout of fifth generation mobile networks is progressing around the world, but 5G looks especially expensive compared to previous generations. Network sharing between two or more mobile operators is an obvious way to attain significant cost savings, but may also raise competition concerns. This paper first distinguishes between early and mature 5G, and then discusses the expected changes mature 5G brings to the assessment of active mobile network sharing agreements from a competition policy point of view. We focus on the three main concerns where 5G may bring the most significant changes in the evaluation compared to 4G: service differentiation, cost commonality between the parties and the parties' ability and incentives to grant access to critical inputs to downstream competitors. For each of these concerns, we show that they are not easy to substantiate and in some cases the concerns may even become less grave than under 4G.

JEL codes: K21, L13, L41

Keywords: mobile telecommunication markets, network sharing, competition policy, competitive assessment, 5G

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A mobil hálózatmegosztás hatása a versenyre: a korai és érett 5G támasztotta kihívások

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ÖSSZEFOGLALÓ

Világszerte zajlik az ötödik generációs mobilhálózatok kiépítése, de az 5G különösen költséges beruházás a korábbi generációkhoz képest. A két vagy több mobilszolgáltató közötti hálózatmegosztás egy nyilvánvaló módja a költségek csökkentésének, de egyúttal versenyproblémákat is felvethet. Ebben a tanulmányban először különbséget teszünk a korai és érett 5G között, aztán azt tárgyaljuk, hogy az érett 5G várhatóan mennyiben változtatja meg az aktív mobil hálózatmegosztási megállapodások versenypolitikai értékelését. Három olyan fő aggályra fókuszálunk, amelyek esetében az 5G a legnagyobb változást hozhatja a megítélésben, ezek: a szolgáltatások differenciáltságának csökkenése, a közös költségek arányának növekedése és a felek megváltozó képessége és ösztönzöttsége arra, hogy downstream versenytársaiknak hozzáférést biztosítsanak kritikus inputokhoz. Mindhárom aggály kapcsán bemutatjuk, hogy ezek nehezen bizonyíthatóak, és az aggályok még enyhülhetnek is a 4G-ig fennálló helyzethez képest.

JEL: K21, L13, L41

Kulcsszavak: mobil telekommunikációs piacok, hálózatmegosztás, versenypolitika, versenyszempontú értékelés, 5G

The impact of network sharing on competition: the challenges posed by early versus mature 5G

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Abstract

The rollout of fifth generation mobile networks is progressing around the world, but 5G looks especially expensive compared to previous generations. Network sharing between two or more mobile operators is an obvious way to attain significant cost savings, but may also raise competition concerns. This paper first distinguishes between early and mature 5G, and then discusses the expected changes mature 5G brings to the assessment of active mobile network sharing agreements from a competition policy point of view. We focus on the three main concerns where 5G may bring the most significant changes in the evaluation compared to 4G: service differentiation, cost commonality between the parties and the parties' ability and incentives to grant access to critical inputs to downstream competitors. For each of these concerns, we show that they are not easy to substantiate and in some cases the concerns may even become less grave than under 4G.

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1. INTRODUCTION

The rollout of fifth generation mobile networks is progressing around the world. In recent years, more and more spectrum bands are awarded, the ratio of 5G-compatible devices is increasing, and mobile operators are signing or contemplating agreements to share the cost burden of 5G network rollout and maintenance. This paper will discuss the expected changes 5G brings to the assessment of such active mobile network sharing agreements from a competition policy point of view.

From each technology generation to the next, mobile networks have become more complex, not only technically, but from a business point of view as well: the investment required for the rollout and operation of a new network is ever greater. 5G, with its wide array of promised features, is especially expensive compared to previous generations. Even assuming growing efficiency in service provision and increasing consumer interest, achieving adequate returns on the investment poses a challenge to operators. Network sharing between two or more mobile operators is one of the most obvious ways to attain significant cost savings, and has become a more and more standard practice from the early 2000s. Under certain conditions, network sharing may even be a necessity to ensure the economic viability of 5G investments. Network sharing can also achieve faster rollout and better coverage.

While sharing brings undeniable advantages to operators and consumers, it may also raise concerns: since the parties are direct competitors, these agreements could potentially lead to a restriction of competition. This competitive assessment, usually carried out by a competition authority or in some special cases a regulatory agency, should evaluate in detail 1) whether the restrictive effects can be substantiated; and if the answer is affirmative, then 2) whether the positive effects brought by efficiencies could still outweigh the negative effects on competition.

It is important to emphasise that each agreement must be assessed based on its own merits and the specific market conditions, but there are some general expectations we can form about the types of concerns that can arise, the important points to consider when evaluating them, their relative severity and the possibilities to mitigate them. Active network sharing is not a new phenomenon and a lot of knowledge and experience has accumulated in assessing sharing agreements up to the fourth generation – we presented an evaluation framework in Pápai et al (2020). However, as the 5G era advances, new concerns may emerge, and certain concerns could become more pronounced while others lose relevance. We describe our expectations regarding these changes in this paper.

First and foremost, an important distinction must be made between early and mature 5G. In our opinion, from the point of view of assessing the effects of network sharing on competition, early 5G rollouts differ only slightly from 4G. Therefore, the assessment framework we developed previously can be usefully deployed for early 5G as well. In contrast, so-called mature 5G should bring a host of new features, services, markets and even new sharing opportunities, and could have a profound effect on the competitive assessment. However, mature 5G is still years away, while sharing agreements extending to 5G are already being concluded. This poses a challenge: the standard forward-looking assessment now must be implemented in a more uncertain future technological environment. In this paper, we take the challenge and make our best predictions on how mature 5G may influence the assessment. These are naturally subject to change as markets and technologies develop.

We focus on three main competitive concerns (so called theories of harm) that we anticipate will be especially relevant in the future assessment of 5G network sharing agreements.

First, we look at the concern that sharing may decrease the differentiation of services between parties. Our most important expectation is that with mature 5G, the role of the core in differentiation will increase significantly compared to previous technology generations (and even early 5G). As a consequence, mature 5G RAN sharing would likely result in a much smaller overall similarity in terms of differentiation compared to 4G and early 5G, diminishing the relevance of this concern. However, the concern is expected to stay on the agenda due to the possible sharing of certain core elements, and also with respect to coverage.

Second, we discuss the concern that the increased commonality of costs may enable tacit collusion on the market. We emphasise that the level of cost commonality could be quite different regarding the services on the emerging distinct relevant markets, so market definition may play an important role in connection to this concern. The level of cost commonality for the widely used general-purpose mobile services (broadband, voice) could be quite moderate even in a case of a widespread 5G network sharing, and therefore the concern may be harder to substantiate. For emerging new mature 5G markets, since these services are expected to be provided for business (or non-profit) customers, the ratio of retail costs within the total cost will likely be much lower than in the case of general-purpose services. This could result in a higher level of cost commonality on a shared RAN infrastructure, implying a more detailed competitive assessment for this type of service.

Third, we look at vertical concerns related to whether sharing parties' ability and incentive to grant access to critical inputs to their downstream competitors will change. Such inputs could be the passive infrastructure, backhaul and wholesale mobile services to virtual operators. While the specifics of the assessments may change, such vertical concerns will remain hard to substantiate and usually easy to fix with commitments. However, it is possible that there might be additional vertical concerns compared to 4G which could merit special attention. Mature 5G will likely create new relevant retail markets focusing on the individual requirements of certain customers, possibly also resulting in the emergence of new relevant wholesale markets. Possible vertical concerns on these new markets may require wider and deeper evaluation later on.

The structure of the paper is the following. Chapter 2 introduces the distinction between early and mature 5G, and provides some technological background to the aspects of 5G that we expect will influence the assessment of network sharing. Chapter 3 describes the state of play for 5G sharing agreements: their motivations, their possible dimensions and the agreements already concluded. Chapter 4 summarises our analytical framework for the competition assessment of mobile network sharing agreements. Chapter 5 shows how we currently expect mature 5G to change the assessment of network sharing agreements through the three main theories of harm. Chapter 6 concludes.

2. AN OVERVIEW OF 5G AND ITS EARLY AND MATURE STAGE

This chapter contains an overview of the main characteristics of 5G mobile services, focusing especially on the attributes that could have an influence on network sharing agreements or their assessment.

Firstly, we will make a distinction between early and mature 5G, then detail how mature 5G is expected to differ from the previous, 4th generation mobile services and from early 5G. Current roll-outs only implement a non-standalone deployment of the 5G radio network, connected to the 4G network. This solution, and even the standalone deployments expected later (where the 5G core also appears in addition to the 5G radio) only result in an early version of 5G. We show that early 5G only attains a small portion of the significant technical and service capabilities expected of mature 5G, and can essentially be characterised as an extension or a complement to current 4G. This implies that the assessment of network sharing agreements pertaining to early 5G should be very similar to the approach used up to 4G.

2.1 THE CHARACTERISTICS OF MATURE 5G

Some operators already started building 5G networks in 2019; these can be referred to as early 5G networks. These networks can, at most, achieve higher broadband speed and more efficient spectrum use compared to 4G. The real technological advancement is expected with the advent of mature 5G. This chapter details its main characteristics.

Mature 5G is not simply faster and more efficient than the previous generation: both its technological implementation and its approach to service provision is significantly different. Up until 4G, all technological generations aimed to provide services to all consumer groups using one general purpose network.[6] With mature 5G, in contrast, several logically separate networks can be flexibly configured, and these networks can then satisfy users with widely varying requirements regarding use cases, service and quality attributes, security and reliability.

Providing such special purpose services requires significant changes and new solutions both in the radio access network (RAN) and the core network. This has consequences for the way networks are built and maintained, the costs involved, and the possibilities and incentives to decrease these costs via some form of cooperation between operators, such as network sharing.

Based on the expected capabilities of mature 5G, new and special markets could emerge (primarily targeted at business clients), in addition to the current mass market services (voice, messaging, mobile internet). At this point, we can only conjecture which services will be commercially successful, based on the slowly accumulating evidence and experience from current use cases.[7]

In general, three use case categories have been defined, each of them with its critical service characteristics requirements. These are the following:

1. Enhanced Mobile Broadband (eMBB), which refers to a targeted significantly higher peak and average data rates and capacity than conventional mobile broadband, with wide coverage. It presupposes data speed in the Gigabit per second range, which is 10-100 times the current 4G speed and up to 1000 times the capacity per unit area.
2. Ultra-Reliable and Low Latency Communications (uRLLC), which provide high reliability and real-time communication services. The target values are 1 millisecond latency compared to the 200 milliseconds for 4G, and 99.999% availability.
3. Massive Machine-Type Communications (mMTC), which designates the service capability of connecting a vast amount of communication devices, with high device density but usually low bandwidth needs. The network has to be capable of handling 106 devices per square kilometre, 100 times that of 4G.

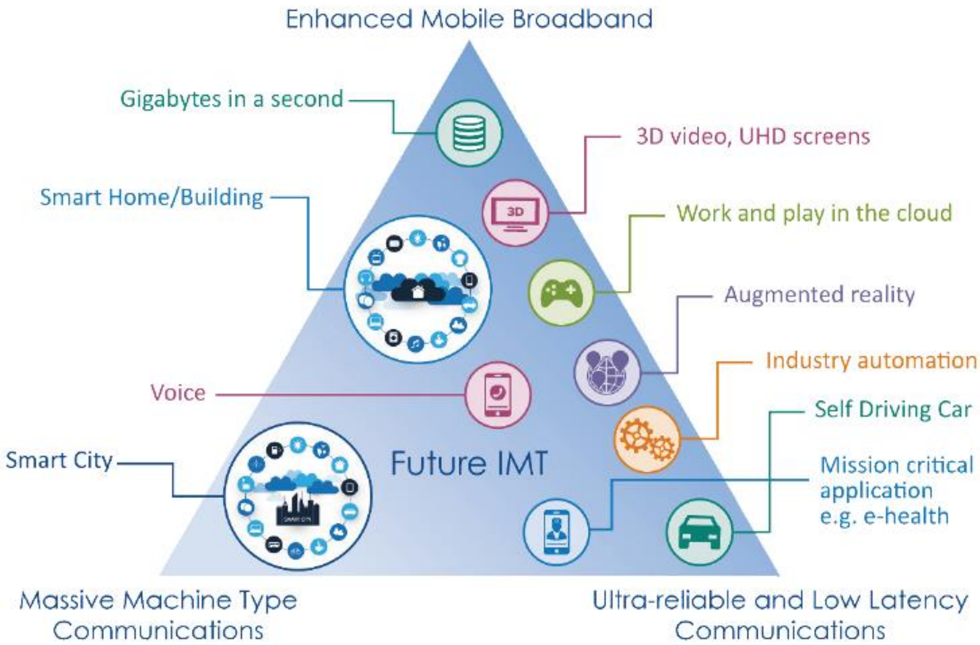
Some possible use cases are mapped into a triangle space below. The corners are the extreme service capabilities of 5G listed above. Normally the services are located somewhere inside the triangle defined by the corners. We consider 5G networks mature if they are capable of providing these services to a large part of the market, achieving outcomes at least close to those target values listed above.

[6] The shift from the „one size fits all" network started with the deployment of the wide area low power massive IoT network technologies, narrowband IoT (NBIoT) and LTE-M under 4G.

[7] See for example: ITU (2018), and for a more lively discussion see: Lehr (2018); in a Q&A form see 'Introducing 5G technology and networks (definition, use cases and rollout)' at https://www.gemalto.com/mobile/inspired/5G (last accessed: June 30, 2020).

Figure 1

5G usage scenarios[8]



As of today, of the three special use case categories, only the functions supporting 5G enhanced mobile broadband are standardised and have started to be commercially implemented, while the others are projected for 2023 at the earliest.[9]

Overall, currently only early 5G is available and this is expected to remain so in the next few years, and early 5G only provides progress in the mass market service of mobile broadband – but even in that case, not even approaching the target values listed above: early 5G networks typically achieve a 10-20% speed increase in comparison to 4G, a far cry from the more than tenfold increase targeted.[10] To reach the target values for eMBB and to introduce uRLLC and mMTC-based services, at least three things are needed: 1. introduction of the 5G core, 2. deploying certain core functions close to the user (such as MEC, see below), and 3. the further development and densification of the RAN network through increasing the number of base stations using sub-6 GHZ spectrum, but later also using the millimetre wave (mmWave) frequencies.

The distinction between early and mature 5G naturally has an effect on the evaluation of potential network sharing agreements as well. Here, we provide an illustrative list of the

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[8] Source: ITU (2018).
[9] See the Fierce Wireless article 'Industry Voices – Pongratz: 5G is not all the same', August 8 2019, https://www.fiercewireless.com/wireless/industry-voices-pongratz-5g-not-all-same, last accessed: June 30, 2020.
[10] See ITU (2015).

capabilities and characteristics of mature 5G that could influence the competition assessment of network sharing.

1. *Virtualisation and Service Based Architecture.* Two architectural principles of the future 5G core are expected to be important: the Software Defined Network (SDN) minimises hardware constraints while Network Function Virtualisation (NFV) decouples hardware and software in deploying new network functions.[11] A new system architecture, the so-called Service-Based Architecture (SBA) enables flexibility in developing and configuring new services without introducing specific new interfaces.[12] This feature of the 5G core plays a key role in the service differentiation capabilities which are much larger and wider in scale and scope than in the case of 4G. This could affect the assessment of the parties' ability to differentiate in a network sharing scenario.
2. *Network slicing.* Based on the new capabilities of the 5G core network slicing creates the opportunity to define special-purpose networks, tailored to serve particular applications and /or user needs as independent end-to-end logical networks, above the common 5G physical network.[13] This opens up markets for new services and use cases. Slicing will definitely increase the ability of parties to differentiate their services, but depending on the way network sharing is implemented, this increase may be constrained somewhat by the sharing.
3. *Multi-access Edge Computing (MEC).* This refers to placing some formerly centralised core computing and processing functionalities (sometimes even physically) right at the edge of the RAN, closer to the end-user. This is the key, for example, to supporting low-latency, reliability-critical uRLLC services. MEC deployment will increase the ability of operators to differentiate even with extensive RAN sharing. However, it could also open up the possibility of sharing extending to some core functions.
4. *Densification.* Densification means increasing network capacity by adding more new cells to the network, which is required for mature 5G. It is achieved through cell-splitting, adding small cells and building new sites. Densification is occurring gradually with the deployment of early 5G in the sub-6 GHz spectrum, mostly in order to enhance the mobile broadband experience. A second phase of densification will start with the extensive deployment of small cells, and the third phase takes place when the millimetre wave (mmWave) spectrum will be put to work. Adding new sites is very costly and could increase the rationale for network sharing.

[11] See Yousaf et al (2017).

[12] See Jari Arkko: Service-Based Architecture in 5G, Ericsson blog, Sep 14, 2017, https://www.ericsson.com/en/blog/2017/9/service-based-architecture-in-5g, last accessed: June 30, 2020.

[13] See GSMA (2018).

2.2 ALTERNATIVE 5G DEPLOYMENT SCENARIOS: NON-STANDALONE VERSUS STANDALONE 5G

Mature 5G, as described at length in the previous section, is several years away from becoming reality. The natural question is why this is the case. We mentioned before that the new services require new solutions with regard to both the RAN and the core. However, the standardisation for these changes is still in progress. Only once standardisation has taken place can manufacturers (vendors) begin to develop and distribute new equipment to MNOs, who can only then commence building their networks.

Regarding the standardisation process,[14] the current situation (as of mid-2020) is the following:

- Release 15 (end of 2018) included standards for 5G RAN, enabling early 5G to commence in 2019.
- Release 16, projected to handle standards for the 5G core, is planned for 2020 (but a certain degree of delay is expected), and not yet released. Some functions are only going to be handled in Release 17.[15]

The situation regarding the standardisation process has resulted in two separate deployment scenarios for 5G. The originally imagined process for 5G deployment, using both the 5G RAN ("5G New Radio") and the 5G core, is called standalone 5G. This means that the 5G network could be deployed completely independently from the current 4G network. This, however, is not possible until standardisation has progressed further. However, Release 15 (in response to MNOs' requests) also enabled an alternative, so-called non-standalone 5G. This is a solution where the 5G New Radio piggybacks on the existing (and evolving) 4G core.[16] In such a way, mobile broadband speeds can be increased (and spectrum use made more efficient), even before the 5G core exists; this is at best the eMBB corner of the triangle. The other use cases cannot be achieved without a 5G core. As a later step, 5G could integrate the 5G and 4G radio networks, and thereby capitalise on the enhanced core capabilities, while still using the universal 4G base coverage.

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[14] Conducted by 3GPP, the 3rd Generation Partnership Project. https://www.3gpp.org/about-3gpp, last accessed: June 30, 2020.

[15] 3GPP: RAN Rel-16 progress and Rel-17 potential work areas, July 18, 2019, https://www.3gpp.org/news-events/2058-ran-rel-16-progress-and-rel-17-potential-work-areas, last accessed: June 30, 2020; 3GPP Release 16, Updated March 23, 2020 https://www.3gpp.org/release-16, last accessed: June 30, 2020; Catherine Sbeglia: 3GPP delays 5G standard updates due to COVID-19, March 26, 2020, RCRWirelessNews https://www.rcrwireless.com/20200326/5g/3gpp-delays-5g-updates-covid-19, last accessed: June 30, 2020.

[16] Dave Bolan: The twisted road to 5G (Analyst Angle), RCRWirelessNews, February 12, 2019 https://www.rcrwireless.com/20190212/analyst-angle/twisted-road-5g-analyst-angle, last accessed: June 30, 2020; GSMA Operator Requirements for 5G Core Connectivity Options. May 2019 https://www.gsma.com/futurenetworks/wiki/operator-requirements-for-5g-core-connectivity-options/, last accessed: June 30, 2020.

Therefore, mobile operators currently have a choice to make between two possible 5G implementation paths, non-standalone and standalone. Let us look at these two choices in a bit more detail.

- Non-standalone 5G has the advantage of being a currently existing network investment option. It also grants more freedom and flexibility to the operators in choosing the pace of 5G coverage roll-out, and to capitalise on the interworking with the established 4G infrastructure. The flip-side is that non-standalone equipment and network solutions will be used, and many legacy devices will have to continue to be supported.
- Standalone 5G is the pure 5G solution. However, to implement it, operators must wait for the freeze of the standardisation process and the appearance of the commercially available standard 5G core equipment, meaning that 5G as a project must be significantly delayed.

Currently it seems a good portion of mobile operators have chosen or are leaning towards the non-standalone path.[17] The fact that many operators have made this choice means that the whole industry may tip in the favour of non-standalone implementation. However, the situation is currently still in flux.

2.3 CONCLUSIONS ON EARLY VERSUS MATURE 5G

We summarise the important differences between early and mature 5G in the following table. As discussed, early 5G is currently a non-standalone implementation, which cannot provide most of the attributes of mature 5G. Mature 5G presupposes the standalone implementation, but also means more than that: beyond the 5G core, further significant network development will need to take place. The new service elements of mature 5G may take some time to become reality even after the standalone deployment has taken place.

Table 1

The main characteristics of early and mature 5G networks

	Early 5G	**Mature 5G**
Deployment scenario	Non-standalone	Standalone
Time frame	From 2019	Expected after 2023
RAN	5G New Radio	5G New Radio
Core	4G	5G
Relationship between 5G and 4G	5G piggybacks on 4G core	Independent
Spectrum used	Sub-6 GHz	Sub-6 GHz and mmWave
Densification	Moderate / Gradual	Widespread
Service Based Architecture and	Not available	Widespread

[17] According to industry expert Dave Bolan, by September 2019 more than fifty operators deployed a non-standalone 5G network. Bolan: Where to next on the road to 5G Standalone? (Analyst Angle), September 8, 2019, https://www.rcrwireless.com/20190908/analyst-angle/road-to-standalone-5g-analyst-angle, last accessed: June 30, 2020.

Virtualisation		
Network Slicing	Not available	Available
MEC	Not available	Available

Overall, we can state the following:

- There is a significant, qualitative difference between early and mature 5G.
- Early 5G closely resembles 4G in its network and service capabilities; overall, it is closer to 4G than mature 5G.
- Mature 5G must be standalone (that is, it requires the 5G core), but even early standalone deployment lacks many of the key technology elements and characteristics which are the necessary features of mature 5G.

These statements are important because they show that differences between early and mature 5G must also be taken into account when assessing network sharing agreements. Agreements specifically restricted to early 5G type services can be assessed similarly to agreements up to 4G. The more significant and novel assessment challenge is posed by mature 5G, which is still years in the future. The assessment must differ not only because of uncertainty about the future, but also because mature 5G is vastly different.

3. RECENT PRACTICE IN 5G NETWORK SHARING

In this chapter, we will briefly delve into the reasons we expect network sharing to remain significant under 5G, especially under mature 5G. Then, we demonstrate the diverse forms network sharing agreements (NSAs) can take, describing their dimensions. Finally, we show a list of NSAs also covering 5G that have already been concluded in Europe as of May 2020.

3.1 INCENTIVES FOR SHARING UNDER MATURE 5G

The central motivation among operators for network sharing is to reduce cost. The cost incentive is especially strong in the case of mature 5G, where high cost predictions are coupled with uncertain revenue streams and thus high risks.

Regarding cost, some modelling results show that the total cost of ownership (the sum of capital expenditures and operating expenditures) for operators in 2024-25 could be twice as much as in 2018. The lion's share of these expenditures will be due to RAN-related developments – that can therefore be shared. Creating a network capable of supporting mature 5G services and characteristics requires, for example, extensive network densification, necessitating new sites, backhaul connections, potential greenfield investment in rural areas and the deployment of small cells in cities.[18]

Regarding revenue, it is uncertain whether the increase in cost can be countervailed with new revenue streams. The average return per user (ARPU) may increase for eMBB services, although it is not clear by how much. Mature 5G services to vertical industries have huge potential, but it is unclear how much the operators can gain of the benefits stemming from these new services.[19]

The uncertainty of the return on investment makes operators cautious, especially regarding the magnitude and timing of the 5G investments. Network sharing can be a good way to reduce cost and risk.[20] In addition, 5G network sharing could have a positive impact on the revenue side also, by enabling faster roll-out and larger coverage compared to the counterfactual scenario, so that revenues can be realised earlier and on a larger customer base.

3.2 THE MAIN DIMENSIONS OF A NETWORK SHARING AGREEMENT

Network sharing agreements differ from each other in a number of dimensions. In most cases, the alternative options within a dimension can be ordered by depth. The overall scope of an agreement is determined by the options within these dimensions. Since there are a lot of different possible scenarios, agreements with differing characteristics in multiple dimensions are hard to compare. Therefore, a case-by-case analysis is always needed to assess the impact of a given agreement on cost savings, efficiencies and ultimately on potential competition concerns.

In the following, we will list and briefly describe the main dimensions with their alternative options. Note that the options within a given dimension cannot be necessarily ordered.

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[18] Densification also motivates network sharing for another reason: it may be unacceptable to the public for each operator to build a huge number of new base stations, setting up antennas, radio equipment and doing the civil work for the necessary backhaul connections. Municipalities may introduce restrictions in building regulations which could make it harder or even impossible for the operators to build their own independent networks in these areas and could even force the implementation of some form of network sharing.

[19] According to industry estimates, the total value of IoT related services could reach 250 billion euro in 2020. However, only 2% of it can be realised by the telecom operators providing the connectivity. See for example the following presentation: https://5grealised.com/wp-content/uploads/2019/04/Andrea-Dona.pdf, last accessed: June 30, 2020.

[20] As an indication concerning the magnitude of the savings, according to a study prepared by BEREC, the cost saving in a MORAN-type sharing scenario can reach 30-35% of the RAN-related cost in case of previous generation networks (see BEREC (2018)). Model results related to 5G developments show a similar extent of possible cost saving due to RAN sharing. See an article on McKinsey from 2018 (Network Sharing and 5G: A turning point for lone riders), https://www.mckinsey.com/industries/technology-media-and-telecommunications/our-insights/network-sharing-and-5g-a-turning-point-for-lone-riders#, last accessed: June 30, 2020, or Schneir et al. (2019). The impact of network sharing could be even higher if, under mature 5G, parties conduct densification jointly.

1. *Network elements or inputs involved:* Passive sharing is a common practice where two or more providers use the same site, tower and in some cases even antennas. Active sharing is a deeper co-operation, that takes two typical forms in practice.[21] Under MORAN-type sharing, the active radio access network (RAN) is also shared, in an addition to the passive elements. Under MOCN-type sharing not only the RAN, but spectrum is also pooled and jointly used. RAN sharing might be supplemented by the sharing of the backhaul infrastructure.
2. *Geographical coverage:* A network sharing agreement may be national, covering most or all parts of the country, or can extend only to certain parts of the country. The latter category might be further subdivided, as there are "regional" agreements, which usually cover municipalities under a certain threshold defined by number of inhabitants, or much narrower agreements covering only white or grey spots (i.e. places with no current coverage at all or places covered only by one of the operators).
3. *Mobile technology generations involved:* There are agreements involving only a single generation of mobile technologies, while others cover all or almost all generations. Extensions of earlier agreements naturally include more generations, but new agreements might be concluded either only for 5G or for more generations as well.[22]
4. *Spectrum bands involved:* This dimension deals with the issue whether an agreement includes only low (sub-1GHz) spectrum bands, or middle or even higher spectrums as well. Usually, there is an interplay between this dimension and the geographical dimension of the agreement.[23]
5. *Organisational form:* The contractual setting of a network sharing agreement will determine the modalities of the co-operation of the parties. The network sharing might be based on a "simple" bilateral leasing-type contract, which will be then evaluated as an agreement by competition law. The network sharing agreement might also involve the establishment of a joint venture of the parties. This can be a *light*

[21] It is theoretically possible for a sharing to extend beyond the RAN, but to our knowledge these practices are still in the planning stage. In mature 5G, two decentralised core functions might supplement a RAN sharing agreement, providing additional options in this dimension. Mobile Edge Computing will bring the calculation capacities closer to the end user, and the Mobile Content Delivery Network (MCDN) will provide content faster and with better quality. Because of certain technological or economic aspects, it might be reasonable or efficient to jointly deploy or operate them.

[22] A new non-standalone 5G network sharing agreement certainly should involve at least 4G, because of the need of the 4G RAN. In contrast, network sharing agreements involving mature (and therefore standalone) 5G might be executed independently of older generations. Legacy generations (2G, 3G) are now mostly complementary to 4G, and the latter might be even phased out in the near future, with the spectrum made available for newer generations.

[23] A network sharing agreement with national scope can be concluded to handle coverage issues with using one or more low frequency bands, while higher frequency bands are not necessarily needed. For agreements covering larger cities as well, middle or higher frequencies might also be needed. Agreements involving small cells will probably include higher frequencies of the sub-6 GHz spectrum. Sharing in relation to higher frequency bands (mmWave) is another level which can be considered in the case of mature 5G.

joint venture, with functions including the planning, development and maintenance of the joint network, which is still likely to be evaluated as an agreement.[24] The agreement might also involve the establishment of an *asset heavy joint venture*, which might in turn be a fully functional joint venture, which is in essence a merger of certain production assets and functions of the parties and thus can be subject to merger control.[25]

Under mature 5G, a further dimension might arise, further complicating the assessment of an agreement. This is connected to other dimensions, especially to the geographical and spectrum dimension:

6. *Densification:* whether an agreement involves the densification of the network (e.g. deployment of small and/or micro cells). The massive need for small cell deployment will only be relevant when higher frequencies will be put to use (expected under mature 5G). In densely populated city areas small cell deployment might necessitate agreements on network sharing, as the possibilities of deployment could be constrained. Densification might be also important in the case of industrial sites, but this will not necessarily necessitate a network sharing agreement and operators may not be motivated to conclude an agreement at all (especially in the case of key account customers). Certainly, extensive densification is not expected to happen in the next few years.

It is important that competition concerns should be analysed for the whole agreement and the specific market environment, because the importance of individual dimensions might differ in the context of a given competition concern and in the whole context of an agreement. Although an overall deeper agreement probably raises more competition concerns, it is not evident that an agreement with more depth in only one of the dimensions raises considerably more concerns or if it raises any problems at all. On the other hand, a deeper agreement probably involves more cost savings and other efficiencies as well. In the end, what matters is the overall competitive impact of the agreement on relevant markets, which should always involve a case-by-case analysis by parties and authorities alike.

3.3 CURRENT AGREEMENTS INCLUDING 5G NETWORK SHARING IN EUROPE

As our assessment framework directly concerns the agreements of the European Union, in the following we will overview the 5G network sharing agreements in the EU (including the

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[24] In the case of a mutual lease or in a light joint venture, the network elements connected to the RAN, investments and in some cases even the operation of the RAN remain with the parties.

[25] In an asset heavy joint venture, network elements connected to the RAN or in certain cases even the spectrum assets will be owned and operated by the joint venture.

United Kingdom with a very similar competition regime).[26] As of April 2020 there are eight such announced network sharing agreements. The table below summarises the main characteristics of the announced agreements, based on the press releases of the companies involved and the news reports about these.[27]

Table 2

The main characteristics of announced 5G network sharing agreements

Geographic Scope	New NSA or an extension of an existing NSA	New	Extension
	Whole country	**BE** 2019 2G/3G/4G/5G | 3 | MORAN | JV **LT** 2019 2G/3G/4G/5G | 3 | MOCN | JV **LV** 2019 2G/3G/4G/5G | 3 | MOCN | JV	**DK** 2G/3G/4G/5G | 4 | MOCN | JV **SE** 2018 2G/4G/5G | 4 | MOCN | JV
	"Regional" - municipalities with number of inhabitants under a certain threshold	**IT** 2019 2G/4G/5G | 4 | MORAN | JV	**UK** 2019 2G/3G/4G/5G | 4 | MORAN | JV **ES** 2019 2G/3G/4G/5G | 4 | MORAN | No JV
	Rural - only white or grey spots	**DE** 2019 4G/5G | 3 | MOCN | No JV	-

key: **Country** #Date of announcement | Technology generations | #No of MNOs | Type | Form

As we can see, the agreements differ widely with respect to their geographic coverage, the technologies and spectrum involved, the depth of the network activities and also the organisational form. However, in our view, there are some patterns worth mentioning.

Firstly, the extensions of the existing Scandinavian NSAs to 5G are nationwide with an organisational form of a "deep" joint venture in each country, which jointly acquire spectrum for the respective companies and also operate and develop their MOCN network.[28] A new agreement in Latvia and Lithuania also went in this direction, covering all of the mobile generations with a nationwide MOCN network in a joint venture.[29] A new agreement in Belgium also covers all mobile generations, but the parties intend to operate a nationwide

[26] There are quite a few NSAs around the world as of April 2020. The most expanded 5G network sharing agreements are arguably those of South Korea or China. Note though, that the regulatory environment and the general policy towards these agreements are quite different in these countries, with a strong backing by the respective governments.

[27] Note, that there might be some inaccuracies in the contents of the table stemming from the fact that the details of these agreements are naturally not fully known to the public.

[28] Source: https://www.tele2.com/media/press-releases/2018/tele2-and-telenor-secure-new-frequencies-and-consolidate-joint-plan-for-5g-network-in-sweden, last accessed: June 30, 2020. Although we have not found any official announcement of the extension of the Danish network sharing, all signs seem to indicate its continuation to 5G.

[29] Source: https://www.tele2.com/media/press-releases/2019/tele2-and-bite-sign-agreement-to-share-networks-in-latvia-and-lithuania, last accessed: June 30, 2020.

MORAN in a joint venture and will continue to have full control over their own spectrum assets.[30]

Secondly, the network sharing agreements in which one of the parties is Vodafone seem to go in another direction, with MORAN sharing not covering the whole country. Such an agreement was finally concluded in Italy between Vodafone and TIM, supplemented by an establishment of a joint venture (INWIT).[31] In the United Kingdom, the earlier (geographically more expanded) agreement between Vodafone and O2 was somewhat reduced in 2019 to not cover the largest cities of the UK. The earlier Spanish network sharing agreement between Vodafone and Orange was extended in relation to 5G to cover municipalities with less than 175 000 inhabitants.[32]

Thirdly, in larger countries active RAN sharing for the covering of white (or grey) spots is an issue because of coverage problems with the 4G network. A network sharing agreement of Germany between Deutsche Telekom, Telefónica and Vodafone aims to jointly build and operate around 6000 new (presumably 5G) cell sites to cover the "white spots" in Germany, that is the spots in sparsely populated regions and along traffic routes with no mobile broadband coverage, with an MOCN.[33]

4. THE COMPETITION ASSESSMENT FRAMEWORK FOR NETWORK SHARING AGREEMENTS

In our earlier paper (Pápai et al (2020)) we presented in detail the competitive assessment framework we applied for the analysis of up to 4G mobile network sharing practices, based on the approach laid out in Article 101 of the European Treaty and the European Commission's Guidelines. Since the general European competition framework will not change due to the coming of 5G, we use this framework as a starting point for 5G network sharing as well. However, since 5G may change the range of affected markets and other characteristics of the industry, the assessment of the issues could be different. In the next sections we briefly present the building blocks of our approach.

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30 Source: https://www.proximus.com/news/Proximus-and-Orange-Belgium-join-forces--to-develop-the-mobile-access-network-of-the-future.html, last accessed: June 30, 2020.

31 Source: https://www.vodafone.com/news-and-media/vodafone-group-releases/news/network-sharing-partnership-with-telecom-italia, last accessed: June 30, 2020.

32 Sources: https://news.o2.co.uk/press-release/o2-and-vodafone-finalise-5g-network-agreement-in-the-uk/, last accessed: June 30, 2020, and https://www.orange.com/en/Press-Room/press-releases/press-releases-2019/Orange-and-Vodafone-strengthen-their-mobile-and-fixed-network-sharing-agreements-in-Spain, last accessed: June 30, 2020.

33 Source: https://www.telekom.com/en/company/details/joining-forces-to-combat-dead-spots-585428, last accessed: June 30, 2020. A similar agreement for 4G is the Shared Rural Network agreed upon by the four mobile network operators and the Government in the United Kingdom. (Source: https://www.gov.uk/government/news/shared-rural-network, last accessed: June 30, 2020.). A governmental program also exists in France now for 4G as well for covering white spots. (Source: https://www.arcep.fr/la-regulation/grands-dossiers-reseaux-mobiles/la-couverture-mobile-en-metropole/la-couverture-des-zones-peu-denses.html, last accessed: June 30, 2020.)

Mobile networks provide many services to final consumers; up until 4G, these all fit into the category of the retail market for mobile telecommunications services. While this market could be sub-segmented in many possible ways, this segmentation has no important effect on the analysis.[34] Under 5G, this unified retail market will continue to be the main focus; however, certain services introduced by mature 5G could bring new markets into the assessment.

Network sharing itself, however, happens not at the retail level, where its effects must be evaluated, but at the production level: in the network, where various passive and active inputs, equipment and services combine to produce upstream mobile services. The specific inputs that can be affected by network sharing are (1) the passive infrastructure (sites, masts, antennas), (2) the radio access network (RAN), (3) sometimes, the radio spectrum (so-called MOCN sharing), and (4) sometimes, the transmission network connecting it to the core network. Importantly, there is no known sharing agreement where any part of the core network (which is the intelligent central part of the mobile network, where the production of the mobile network service is completed using the above inputs, and where the differentiating features of the service are added) is involved. This means that an NSA already at the outset raises much smaller competition concerns compared to a frequent scenario used in ongoing discussions by authorities, namely a merger between the MNOs.

Apart from the specific inputs involved, network sharing agreements can differ from each other in other dimensions, such as the mobile technology generations involved, or the geographical scope of the agreement (e.g. pertaining only to rural areas, covering the whole country, or somewhere in between, for instance leaving large cities out of the sharing).

Since an NSA is an agreement between direct competitors, the natural starting point of any competition policy assessment in Europe is the framework established for horizontal agreements, handled in Article 101 TFEU.[35] The burden of proof concerning whether the agreement may have any restrictive effects and thus breach Article 101(1) lies with the competition authority. The Horizontal Guidelines issued by the European Commission in 2010 presents the legal and economic arguments to be considered for the assessment of horizontal agreements.[36] Note that in order to substantiate negative effects, a loss of competition and consumer welfare compared to the counterfactual future scenario without the NSA needs to be proven.

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[34] Possible segmentations include voice and text / data / machine-to-machine communications, or business / residential. Recent mergers, however, always considered the market to be unified, or reached no definitive conclusion. See for example T-Mobile/Orange UK Case COMP/M.5650; Hutchison 3G Austria/Orange Austria Case COMP/M.6497; Hutchison 3G UK/ Telefónica Ireland Case COMP/M.6992; Telefónica Deutschland/ E-PLUS Case COMP/M.7018; Hutchison 3G Italy/ WIND / JV Case COMP/M.7758; T-Mobile NL/Tele2 NL Case COMP/M.8792; Telenor/DNA Case COMP/M.9370.

[35] If the network sharing agreement is in the form of a fully functional joint venture, then the NSA should be evaluated as a merger.

[36] See European Commission (2011).

Should competitive concerns be established, the agreement can be still exempted if the benefits (efficiencies) generated by the NSA outweigh the negative effects. In this paper, however, we only present the framework on anticompetitive concerns.

4.1 THE CLASSIFICATION OF THE POTENTIAL ANTICOMPETITIVE CONCERNS

As the focus of an NSA is the joint use of production assets, it can be characterised as a production agreement. Chapter 4 of the Horizontal Guidelines deals specifically with these types of agreements, so we build on the potential concerns raised therein. The theories of harm can be grouped into three main categories:

1. The agreement may decrease each involved party's individual incentive to compete, and therefore could result in a loss of rivalry between the parties. Following the classical terminology used in merger cases, we refer to these concerns as unilateral (or non-coordinated) horizontal effects.[37]
2. The agreement could lead to a qualitative change on the market such that tacit collusion (between all major operators) becomes easier, more stable or more effective on the market. We refer to these concerns as coordinative horizontal effects.
3. The agreement could change the ability and / or the incentive of any party involved in the NSA to make access to an element of its mobile network infrastructure or service impossible or more expensive for competitors, which could indirectly have a harmful effect on the retail market. These exclusionary concerns will be referred to as vertical effects.

The table below shows a list of competition concerns (theories of harm) that were discussed in detail in our previous paper. On top of the three main categories above, we also included one that cannot be easily fit into the classic framework, but emerged in some recent cases: the unfair competitive advantage.

Table 3

Theories of harm in connection to NSAs

Horizontal unilateral effects	*Decrease in ability and incentives to compete due to the decreased differentiation of services between parties*
	Decrease in incentives to compete due to fixed costs becoming variable
Horizontal coordinative effects	*Increased commonality of costs*
	Information exchange
Vertical effects	*Access to MNOs to passive infrastructure*
	Wholesale access to MVNOs to the operators' network
Unfair competitive	*Potential exclusion of operators not party to the NSA*

[37] Note that just because both parties' behaviour can change because of the agreement (and likely in the same direction), as long as the effect in question follows from changed individual incentives and not from any (tacit) collusion, it is a non-coordinated effect.

advantage	*Excessive concentration of spectrum*

These competition concerns differ from each other in how serious they are and how easily they can be mitigated, handled and resolved if they arise. Here, we briefly describe only those three concerns which we believe will especially relevant in the assessment of 5G network sharing.

Among the horizontal unilateral effects, the concern related to differentiation is the one most frequently raised by regulatory and competition authorities. The concern is that due to the NSA, certain aspects of the operators' services will become more similar to each other, their technical autonomy will decrease and the ability and/or incentive to differentiate will also decrease.[38] The loss of differentiation might imply a loss of competition. This statement in itself is too general, and one would need to specify what aspects of the services could be affected, and to what degree. Operators' services differ from each other in many ways; such as price, marketing strategies, range of services, data allowance, speed, quality, coverage. A few of these differences are related to the radio network (like coverage), some are dependent on the quality and quantity of spectrum used, and many are the result of the capabilities of and the settings in the core (unaffected by NSAs). Overall, we believe the issue of lost differentiation will always be one of the main topics investigated in connection to NSAs. Substantiating a decrease in competition and consumer welfare is not easy from an analytical point of view, however.

Secondly, looking at coordinative effects, an NSA necessitates some degree of information exchange, both during its initial design and also later in its operation and decision-making regarding expansion and further developments. However, there is a potential concern that sharing information can facilitate a collusive outcome, or make it more stable, especially by increasing market transparency.[39] There are good ways to mitigate this naturally arising concern, however: the scope of the information exchanged must be minimised, and the type of information shared must be restricted as well as the group of people with access to it.

Finally, the vertical concerns related to access: some competitors rely on access to relevant upstream infrastructure in order to be able to provide their downstream services. The question is whether the NSA would have the effect of changing the ability and/or the incentive of any party involved in the NSA to make access to an element of its mobile network infrastructure or services impossible or more expensive for its competitors at the given vertical level. Such elements could be the passive infrastructure, or wholesale mobile services to MVNOs. Here, if the concern is raised and substantiated, there are typically commitments

[38] See L'Autorité de la Concurrence (2013) as an example of this concern being raised.
[39] See European Commission (2011), Chapter 2.

that NSA participants could make with regard to providing the required access in a fair and equitable manner.

4.2 AN EMERGING THEORY OF HARM: DECREASE IN THE ABILITY OR INCENTIVE TO INNOVATE

In addition to the concerns listed above, a further horizontal unilateral effect has started to gain traction over the past few years in other fields of competition policy, especially in the evaluation of mergers, that might be also applied to network sharing agreements. According to this concern, horizontal integration (a merger or an agreement) could decrease the parties' ability or incentive to innovate.

The "classic" innovation concern was investigated in some recent merger cases,[40] notably in Dow/DuPont,[41] a merger between two agriculture and chemical companies. The Commission's in-depth investigation essentially created a five-step, cumulative test for whether and how the innovation concern can apply. These steps specify that (1) innovation must be an important parameter of competition in the industry, (2) the parties must be important innovators, (3) they must be close innovation competitors, (4) the merger must have a significant effect on competition already in the short run, and (5) the remaining competitors must be unable to compensate for the loss of competition.[42]

This theory of harm cannot be applied automatically to mobile telecommunications markets, even though there are some elements of innovation in this industry. To make sense of this concern, it is first important to make clear what kind of innovation is at stake here. The innovation that first comes to mind, that of developing new technologies, is not actually in the hands of the MNOs, but the equipment manufacturers, the so-called vendors. The vendors sell the more advanced equipment to operators when they next need or wish to replace theirs. Active equipment has a lifespan of a few years, and therefore innovations will be introduced within a relatively short time span irrespective of the NSA.

Despite the above, the innovation concern has recently arisen at the conceptual level in the BEREC Common Position on Mobile Infrastructure Sharing published in 2019,[43] a document that has had a considerable effect on recent debates on network sharing.[44] According to BEREC, the innovation in question would concern introducing network

[40] See for example Case COMP/M.7268 GE/Alstrom or Case COMP/M.6166 Deutsche Börse/NYSE.
[41] See Case COMP/M.7932 Dow/DuPont.
[42] A good discussion can be found in the 2018 EU speech by Carles Esteva Mosso, see https://ec.europa.eu/competition/speeches/text/sp2018_05_en.pdf, last accessed: June 30, 2020.
[43] See BEREC (2019).
[44] The European Commission also mentions it in its 2019 Statement of Objections concerning the Czech operators' sharing agreement, according to their press release: https://ec.europa.eu/commission/presscorner/detail/en/IP_19_5110, last accessed: June 30, 2020.

improvements and new technologies and services. It just mentions, but does not really detail or substantiate two mechanisms whereby incentives to innovate and invest could decrease:

1. Sharing agreements could „negatively impact incentives for participants to invest in their own infrastructure, as any gains in service offering (relating, for example, to coverage, network quality etc.) resulting from a new investment are likely to be shared with other parties involved."
2. The greater coordination needed between parties „might lead to delays in deployment, as joint decision-making processes can add a layer of bureaucracy to the already complex process."

Overall, in our view, the application of the innovation concern to network sharing agreements is not well fleshed-out. However, we believe it will continue to arise in the future, justifying the addition of this concern to our earlier assessment framework.

5. DISCUSSION OF MORE IMPORTANT COMPETITION CONCERNS WITH NETWORK SHARING IN THE 5G ERA

All the theories of harm discussed in the previous chapter could conceptually arise in connection to 5G network sharing agreements as well. However, the fact that an agreement extends to 5G could also change the way a given concern is assessed. In this chapter, we focus on those concerns where we expect mature 5G to have the greatest impact on assessment: the differentiation concern, the issue of cost commonality and vertical issues.

In addition to the three main concerns listed above, it is also worth mentioning the innovation concern introduced in Chapter 4.2. The recent competition and sectoral regulatory approach raises the possibility that this concern may also receive more attention in connection to 5G agreements. However, this does not mean that this concern will definitely be very significant or that it could be easily substantiated. Overall, there is much uncertainty regarding how the assessment of this relatively new (and so far, merger-specific) concern will progress irrespective of 5G, therefore we do not speculate further on it.

5.1 THE LOSS OF DIFFERENTIATION CONCERN UNDER MATURE 5G

The differentiation concern claims that due to the sharing of network inputs, certain aspects of the operators' services will become more similar to each other, their technical autonomy will decrease and therefore the possibility and/or incentive to differentiate will also decrease. This loss of differentiation might imply a loss of rivalry.

Let us start with the issue of differentiation in coverage. Since 5G deployment requires building a new network, 5G coverage will gradually increase during the RAN roll-out phase from zero to a high percentage for each network. This feature is true for any network generation and is not specific to 5G. We discuss it, however, because during this temporary roll-out phase, competition in coverage may seem especially important, and will quite probably attract the attention of competition authorities and regulators. We make two points in connection to the issue:

- MNOs, whether they are sharing or not, are highly incentivised to increase their coverage as fast as possible, in order to be able to earn revenue.
- During the roll-out process, *similarity* in coverage caused by sharing is not in itself a competitive concern; it could be considered problematic only if coverage is lower than it would have been absent the agreement. In fact, sharing can result in the exact opposite of what the concern implies: by increasing the cost efficiency of the investment, the NSA could enhance the parties' incentives to achieve faster deployment and larger and better-quality coverage.

Now, we look at how the degree of possible ways to differentiate is expected to change between sharing parties under mature 5G. We emphasise two aspects of the situation up until 5G:

- We make a distinction between two main (occasionally interrelated) types of service differentiation: technical and commercial. Commercial differentiation mostly takes place at the retail level, which is unaffected by network sharing.[45] In the case of technical differentiation, however, the RAN and the core have a part to play, but the core is responsible for the major part of it.
- The so far existing NSAs involved, partially or completely, the passive infrastructure, the RAN and transmission, but not the core.[46]

Both of these aspects may well change with mature 5G.

First, with mature 5G, a shift will take place in the relative importance of the RAN as opposed to the core in differentiation: the role of the core will increase significantly compared to previous technology generations (and even early 5G). Mature 5G sharing would therefore result in a much smaller overall similarity in terms of differentiation compared to early 5G, which diminishes the relevance of this concern. The increasing weight is the result of the new essential features and functions of 5G technology. We list a few examples:

- New core features such as Virtualisation and the Service Based Architecture are specifically designed to facilitate flexibility in developing and configuring new services – that is, differentiation.

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[45] Commercial differentiation involves, for example, pricing, creating appealing bundles of products, and other elements of marketing strategies.

[46] Standards laid down by 3GPP allowed the possibility for partial sharing of the core, but no such agreement was ever made. See BIPT (2012) for a discussion.

- The decentralised 5G core network elements such as MEC or MCDN systems will increase the differentiation possibilities in terms of services and service characteristics, and can be built and operated by the sharing parties independently of each other.
- Slicing, one of the most important new developments in 5G allows for providing a virtual private network as a service to business, government or other customers, again, an important differentiator. Slicing is primarily configured and provided independently even if the RAN is shared.

Overall, our expectation is that the relative weight of the RAN in ways to differentiate will likely diminish, and therefore the differentiation concern related to NSAs involving mature 5G is also expected to become less relevant than for NSAs in 4G and early 5G.

Second, when we look at what vertical levels (and to what extent) active network sharing will involve, we expect two shifts with mature 5G.

1. Broader choice in RAN sharing configurations: mature 5G increases the number of dimensions in which parties can decide to share or not to share. Parties can thus fine-tune their agreement better, and a possible differentiation concern can be handled more easily.[47]
2. Possible sharing of core elements: mature 5G may create the opportunity and rationale to at least partially share certain elements of the core (e.g. the mobile edge computing infrastructure). Such a possibility extends the domain of sharing, and could exacerbate the differentiation concern. It is important to remember, however, that we are only discussing *partial* core sharing. However, since even partial sharing of this kind is a completely new possibility, it is hard to assess its effects on the assessment in advance.

In sum, our opinion is that the differentiation concern will likely ease due to the increasing weight of the core under mature 5G sharing, which we consider to be the key development in connection to this concern. However, regulators may likely be still interested in these questions due to the possible sharing of certain core elements, and also with respect to coverage. While we cannot make exact predictions, and it is not yet clear what shapes mature 5G NSAs will take, on balance we expect that the differentiation concern will be less acute under mature 5G than previously, and more difficult to substantiate for competition authorities and regulators.

[47] To list some examples: parties can opt for sharing the network for coverage, but not for capacity; sharing macro sites but deploying small and/or micro cells unilaterally; sharing the RAN for sub-6 GHz spectrum, but not for mmWave, etc.

5.2 THE COST COMMONALITY CONCERN UNDER MATURE 5G

Network sharing agreements can increase the commonality of costs to a level which may potentially enable MNOs to engage in some form of tacit collusion. The EC Horizontal Guidelines specifically mention this issue, but unfortunately it does not define any threshold regarding the level of cost commonality above which this concern can be substantiated.[48]

Regarding NSAs concerning 5G, the most important elements in the scope of the agreement that can impact the level of cost commonality are the following:

1. *Technology generations*. Consolidating parties' full grids including all technology generations leads to the majority of total network costs becoming common (except the relatively moderate core-related costs). In contrast, network sharing including only 5G leads to a significantly lower level of common cost. Even in this case, however, the level of cost commonality could increase in the future since the use of 5G will grow as other technologies are switched off.
2. *Spectrum bands*. Similarly, cost commonality can be lower if the agreement refers only to the network on some specific 5G spectrum bands (e.g. if only the 700 MHz network is shared).
3. *MORAN or MOCN*. In a MORAN-type agreement, the spectrum is not shared, therefore the significant spectrum costs do not become common, as they would in an MOCN agreement.
4. *Geographic scope*. A high portion of the network costs are related to coverage, therefore there is a direct relationship between the geographic scope of the agreement and the level of cost commonality.
5. *Densification*. Besides developing basic coverage, mature 5G requires very costly instances of network densification (likely including deployment of a large number of small cells). The level of cost commonality is highly dependent on whether the parties conduct the densification jointly or independently.

In summary, the wider the scope of the agreement in the dimensions mentioned above, the larger the proportion of total network costs which become common. However, it is important to remember that the level of cost commonality should be evaluated by comparing the common costs to the total cost of services (including retail costs) provided in a downstream relevant market. Costs related to the core and to retail which represent a

[48] European Commission (2011), see for example paragraphs 35-36.

significant part of the total costs of the final products do not become common,[49] so cost commonality can be relatively moderate even if the scope of network sharing is large.

Additionally, the level of cost commonality could be quite different regarding the services on the emerging distinct relevant markets, so market definition may play an important role in connection to this concern. Firstly, let's look at mature 5G eMBB services. These may be on the same relevant market as current general-purpose mobile services provided on other technology generations. Therefore, the level of cost commonality for these general-purpose mobile services could be quite moderate (especially if other technology generations are not shared) even in a case of a widespread 5G network sharing. Secondly, let's look at emerging new mature 5G markets. Since these services are expected to be provided for business (or non-profit) customers, the ratio of retail costs within the total cost is likely much lower than in the case of the general-purpose services. This could result in a higher level of cost commonality on a shared RAN infrastructure – but again without exact thresholds, it would be impossible to say whether it would be so high as to warrant competitive concerns.

However, a large part of network developments necessary for introducing new mature 5G services – e.g. the deployment of Mobile Edge Computing or local densification of the network around business sites – can be implemented unilaterally even if the RAN providing the basic national 5G coverage is shared. In this case, the majority of network elements required by the new mature 5G services is provided unilaterally and independently, and the level of cost commonality could be minimal.

Overall, we believe that the competition concerns regarding commonality of costs will arise in the evaluation of 5G network sharing agreements, but it is not at all trivial that these concerns can indeed be substantiated.

5.3 VERTICAL CONCERNS UNDER MATURE 5G

Vertical concerns emerging in connection to 5G agreements could include denial of access to (or raising the price of) critical upstream inputs for downstream competitors to foreclose the market. Such inputs could be the passive infrastructure, backhaul and wholesale mobile services to virtual operators. Note, however, that substantiating vertical concerns and harms to consumers is usually a very hard task, as we already discussed in Chapter 4.

First, regarding passive infrastructure, sharing has been a widespread practice among the MNOs in all mobile markets since the early 2000s. As a starting point, 5G active network sharing likely does not change operators' incentives (if any) to deny access to existing sites and such denials are also prohibited by regulation in most markets.

49 Unfortunately, very little information is available regarding the ratio of core-related and retail costs. In a recently published study, the authors make some assumptions for a hypothetical business case, based on industry information and Vodafone data, but these can hardly be generalised. See Schneir et al (2019).

The other concern related to passive infrastructure could be that the parties to an NSA may dismantle sites while consolidating their networks, thereby decreasing the infrastructure supply available to other MNOs. However, if the NSA relates exclusively to the deployment and operation of the new 5G RAN, then this concern is very unlikely to arise: the roll-out of a new network will likely require new sites, and not the dismantling of previous ones. However, the concern may warrant more attention if the 5G NSA also includes other technologies and results in the full consolidation of the parties' RAN.[50] But even in this case, mitigation is possible since the parties can easily offer commitments to alleviate the concerns e.g. by offering the unused passive infrastructure to rival MNOs for sale or lease.

Additionally, passive infrastructure may have a larger chance of becoming a bottleneck in a few years' time, in relation to the densification of the network required by mature 5G, especially in high-population areas. Currently, the majority of infrastructure elements (rooftops, lamp posts, etc.) which could serve as locations to deploy passive infrastructure are private or owned by municipalities. Municipalities can introduce restrictions in building regulations which could make harder or even impossible for the MNOs to build their own independent physical networks in these areas and could indirectly force them into engaging in some form of network sharing.[51]

Second, backhaul and especially fibre backhaul will likely become a more important input for 5G operators as growing traffic and site numbers (especially in the case of mature 5G) require a significant increase in the number and capacity of backhaul connections. This may draw more attention to the evaluation of the potential vertical effects on these markets. At this point, we believe that proving the change in parties' ability/incentive to foreclose their rivals could be difficult for the competition authorities. If needed, parties can offer commitments to alleviate any concerns, but sector-specific regulation can also take measures to prevent the emergence of negative effects.

Finally, the provision of wholesale mobile services for virtual operators represents the third vertically related market where concerns may arise. Up until the early 5G era, the concerns would relate to the market of traditional MVNO wholesale services, where virtual operators seek wholesale services to serve their retail consumers. However, as we mentioned earlier, mature 5G will likely create new relevant retail markets (focusing on the individual requirements of certain customers), possibly also resulting in the emergence of new relevant wholesale markets. Therefore, it is likely that the characteristics of these corresponding wholesale markets will be different from current MVNO wholesale service markets. It is too early to discuss potential vertical effects on these markets at the moment – since their

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50 See e.g. the recent NSA case in Italy.

51 In some cases, only active network sharing is able to solve the problem since it results in the reduction of MNOs' equipment installed on the sites.

characteristics cannot be exactly predicted. We believe, however, that possible vertical concerns on these new markets may require wider and deeper evaluation later on.

6. CONCLUSION

This paper set out to show how we expect the assessment of mobile network sharing agreements to change due to 5G. We conclude that agreements specifically restricted to early 5G-type services can be assessed using the assessment framework we presented for agreements up to 4G. The assessment challenge is posed by mature 5G, which is still a few years in the future.

We looked in more detail into the three theories of harm whose assessment is expected to be impacted the most by mature 5G. The first is the concern that sharing may decrease the ability and incentive for parties to differentiate their services from each other. The second is the concern that the increased commonality of costs may enable tacit collusion on the market. And finally, the so-called vertical concerns are related to whether the ability and incentive of sharing parties to grant access to critical inputs to their downstream competitors will change. For each of these concerns, we show that they are not easy to substantiate, and in some cases the concerns may even become less grave than under 4G.

Overall, the 5G rollouts we see today have little in common with the mature 5G to come. However, network sharing agreements will in all likelihood be part of the picture, and discussing their possible merits and drawbacks can go a long way in reducing uncertainty on the market. This paper is an early endeavour at posing questions and drawing some conclusions about the assessment of the sharing agreements of the future.

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