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Financial and regulatory assessment of Mobile Network Sharing as a trigger of cost efficient 5G rollout in CEE

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Financial and regulatory assessment of Mobile Network Sharing as a trigger of cost efficient 5G rollout in CEE

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Disclaimer: This article was written by Gábor Földes. Views are the author's own and do not necessarily represent the concluded position of NMHH on particular matters.

Abstract

Telecommunication sector faces to parallel investments into both fiber and 5G, however due to monetization challenges, return on investments often lag behind normal profit expectations. Co-investment, like mobile network sharing can promote cost efficiency, however cooperation raises regulatory concerns related to competition and innovation in the EU.

The purpose of this paper to assess the Czech and Hungarian mobile network sharing agreements in CEE that both show higher degree of cooperation, therefore not cleared by the competition regulations, however has been placed in unchanged form for 8 years.

The research question is to assess the procompetitive and anticompetitive theoretical aspects and actual impacts of opposed cooperation in terms of net effect, whether benefits outweigh potential drawbacks in particular to foreseen 5G rollout.

The research methodology covers the empirical comparison of Czech and Hungarian market data related to market shares, prices and data traffic volume, as well as network quality data on coverage and capacity in 2014-2021-time frame.

The main finding is that, although live network sharing agreements have been opposed, main anticompetitive effects could not be justified, and majority of procompetitive benefits fails to be rejected, with the exemption of efficiency gains pass through customers that remains unclear. Despite of benefits may outweigh potential drawbacks even in these not recommended cases, due to lack of regulatory clearance, the 5G rollout launched without sharing, causing social welfare loss.

The originality of the paper that it provides an empirical research on such a live network sharing case that is not recommended and not cleared, as sharing contains active network elements and even spectrum, highlighting that even these cases' procompetitive advantages may outweigh anticompetitive ones.

Keywords: 5G, mobile network sharing, cost efficiency, coopetition, competition regulation

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1. Introduction

The role of corporate cooperation, like mobile network sharing has received increased attention across a number of disciplines in recent years. The widespread of 5G mobile broadband internet is an EU level ultimate aim, however the optimal way to there is not clear. Corporates require more cooperation and even consolidation for higher economies of scale, however regulation put a stress on competition and innovation that expectations need to be harmonized.

This paper has been divided into six parts. **The first, introduction part** deals with the current status of EU 5G rollout and the key driving factors from corporate and regulation sides. From cost efficiency initiatives the Mobile Network sharing and its main types described. In the **second part, the literature review** proceeds the cooperation and co-investment forms, the mobile telecommunication market structure, telco sector and competition regulation related to procompetitive and anticompetitive theories, net effects and recommendations. **The third part** covers the description of research sub questions and related measures, as well as quantitative empirical research methodology. In **the fourth, discussion part** the Czech and Hungarian Network Sharing Agreements and their regulatory evaluation are introduced. **The fifth, results chapter assesses** measurable procompetitive and anticompetitive effects in the Czech and Hungarian cases. **The sixth, final, conclusion part** summing up the novelty finding that despite Network Sharing Agreements opposed and not cleared, the benefits might overweight competition concerns, and benefit loss is foreseen related to 5G rollout due to the absence of extended NSAs.

Mobile Telecommunication Operators (MNO) face to parallel rollout of fixed (FTTH) and mobile (5G) networks, driven by **data increase**, predicted CAGR 24% mobile data growth in CEE between 2021-2027 (Ericsson Mobility report [2021]). Expectation of enhanced mobile broadband (eMBB), the ultra-reliable low-latency communications (uRLLC) and massive machine-type communication (mMTC) as well as 5G micro cell density further increase Total Cost of Ownership (TCO). However Mobile Generations' lifecycles are shorter and overlapping, therefore Return on Capital Employed (RoCE) worsening, lagging behind expected normal profit, Weighted Average Cost of Capital (WACC), driving one of the lowest EV/EBITDA (Enterprise Value / Earnings Before Interests, Taxes and Depreciation) valuations for telecoms, reaching only 5-8 times multiplier compared 10-20 in other industries (Arthur D. Little [2021]). As data monetization and revenue increase uncertain, focus is on operational and

capital expenditures (OPEX and CAPEX) to **increase productivity, cost efficiency and improve economies of scale.**

The technology development enables new cost efficient business models, where savings coming from *(i)* operator-operator collaboration, like horizontal agreements (Network Sharing) and asset reconfiguration (spin-off TowerCos and FiberCos), *(ii)* operator-vendor relationship reassessment by open RAN (multivendor selection), and *(iii)* operator-hyperscalers (BigTechs, public cloud providers) relationship set-up by virtualization of Core and RAN.

In this paper the assessment of Network Sharing is covered and Tables 1. shows the main dimensions of **Network Sharing Agreements (NSA)**.

Table 1. Overview on NSA types

Dimensions of RAN related Network Sharing Agreements (NSA)		
#	Dimensions	Sub-categories
1.	Technology domains	<ul style="list-style-type: none"> ▪ passive infrastructure elements: towers, masts ▪ additionally active infrastructure elements, like radio – Multiple Operator Radio Access Network (MORAN) ▪ additionally spectrum – Multiple Operator Core Network (MOCN)
2.	Spectrum bands	from a certain spectrum layer, e.g., 800 MHz to full scope
3.	Technology generations	from a certain generation, e.g., 4G to full 2-5G range
4.	Areas	<ul style="list-style-type: none"> ▪ density (rural, urban, exemptions, like capital) ▪ ratio of covered territory (geographic area) ▪ ratio of covered inhabitants ▪ the way of sharing, e.g., geographical split
5.	Market context	<ul style="list-style-type: none"> ▪ number of operators (on the market; participating in NSA) ▪ position of participating operators (market shares) ▪ market concentration (HHI index)
6.	Operational model	<ul style="list-style-type: none"> ▪ cooperative model (e.g., Joint Ventures) ▪ contractual model (e.g., reciprocal, one-way sharing) ▪ transfer pricing (public, cost based versus any other cases)

Dimensions of RAN related Network Sharing Agreements (NSA)		
#	Dimensions	Sub-categories
7.	Duration	Temporary or mid/long term
8.	Driver	Commercial benefit or regulatory imposed

Source: Author’s summary

In practice the main cases handled by regulation are **passive sharing** and **active sharing** (MORAN), but additional spectrum sharing (MOCN) many cases ruled-out. The higher the scope, the higher is the financial benefit (saving) and parallel the highest the potential restriction impact on competition and innovation incentives. The higher scope preferred by MNOs, the smaller scope preferred by regulators.

From industrial organizations and corporate finance aspect the expected network sharing’s cost efficiency impact is summarized in Table 2.

Table 2. Overview on cost savings per NSA types

	Blended CAPEX&OPEX savings by NSA types		
	Passive	MORAN	MOCN
Analysys Mason	N/A	30-40%	40-50%
Deloitte	16-35%	25-35%	30-45%
McKinsey		upto 40%	

Source: Author’s summary based on Deloitte [2020], McKinsey [2018], Telefonica [2019]

The expected network sharing’s cost savings may exceed one third of CAPEX and OPEX. NSAs contribute to TCO decrease, as no parallel RAN infrastructure built, therefore utilization increases, resulting better RoCE, and the network sharing Joint Ventures awarded by remarkable higher EV/EBITDA, exceeding 15 times multiplier, compared to 5-8 range of traditional MNOs (Arthur D. Little [2021]).

The regulation has dual aims: on one side encourages investments and higher coverage, on the other hand preserves incentives for competition and innovation.

Sector regulation (National Regulatory Authorities – NRAs), represented by Body of European Regulators for Electronic Communication (BEREC) at EU level, has equal focus on

meeting Digital Decade 2030 connectivity targets (Very-High Speed Networks [VHCN] coverage: 100% of EU households covered by Gigabit network; 100% of population covered by 5G) in a cost efficiency way, as well as maintain incentives for preferred infrastructure-based competition and innovation.

Competition regulation (National Competition Authorities – NCAs) main focus is to prohibit such cooperation that may prevent, restrict or distort the competition, that may decrease social welfare. However it handles exemption, where the restriction of competition kept at minimum level and compensated by technical or economic benefits, from which fair share pass through to customers. In other words, cost efficiency benefits considered just on those cases if it outweighs potential competition drawbacks.

As a mixed consequences of corporate and regulatory ambitions in 2021 EU lagged behind in terms of both the 5G population coverage (EU 63% versus 81-94% range) and the 5G share of all mobile connections (EU 3% versus 7-29% range), based on the current status of 5G progress compared to US, Japan and South Korea. This was the main finding of European Telecommunications Network Operators (ETNO) study, based on Analysys Mason research (ETNO [2022]).

The next literature review provides the research framework for telco market, relevant legal baseline and recommendations related to NSAs.

2. Literature review

Earlier there were relatively few historical studies in the area of cooperation in telecommunication, but in the last five years growing body of literature has investigated this topic. In my literature review I focus on those key-research findings that are most adoptable for the Czech and Hungarian NSA assessment from procompetitive and anticompetitive aspects.

At first, I take the focus to literature on cooperation forms, review of telecommunication value-chain, market structure as well as the competition-innovation-investment relationship. Secondly, I show the NSA relevant legal framework from sector and competition regulation point of view. Thirdly I summarize recent studies related to NSA benefits (procompetitive aspects) and drawbacks (anticompetitive concerns) and potential nettings. Finally, I highlight the literature based theoretical level key-recommendations of NSAs to be approved by regulators.

2.1. Cooperation forms

Mobile Network Sharing Agreements from competition policy point of view belongs to merger and horizontal agreement categories. From industrial organization aspects the literature refers to it under cooperation definition. The telecommunication sector regulation refers for the cooperation as co-investment.

Mergers and horizontal agreements

A **merger** is an agreement between two existing companies to form a new legal entity under one corporate name. The **horizontal merger** is a merger between competitors. Based on Motta [2003], in case of studying the effects of horizontal mergers also two main considerations have to be taken. The merger has to be evaluated whether the merged firm can unilaterally (non-coordinated) exercise market power and raise prices, as well as whether can apply pro-collusive (coordinated) actions that might substantial lessen the competition and raise prices. The **horizontal agreement** is a softer form of horizontal merger, when competitors create a new entity (Joint Ventures - JV) that carries out some activities instead of the partners. A horizontal agreement also can be a contractual based, without forming a JV. There are several activities that could be made the object of the JV, like research and development, or production. The NSA is handled as a **horizontal production agreement**.

Motta and Tarantino published a study related to merger between two firms in an oligopolistic market, which is a closer case to telco market. They studied the prices and investment impact of the NSA between two firms in oligopoly. The NSA corresponds to a joint venture, in which firms coordinate their investments but compete in prices. It can be considered also as a case of an incomplete merger, in which cooperation only related to the decision on how much to invest for cost reduction, without coordination of prices, which can be applied for NSA. Motta and Tarantino found that in general NSAs tend to be better for consumers, than mergers, from social welfare point of view. (Motta, M., Tarantino, E. [2017]).

A recent theoretical contribution by Maier-Rigaud *et al.* [2020] distinguished mergers and a horizontal agreements (like NSA) as the following: mergers allow firms to coordinate on pricing and any other commercial decision, for example regarding investments, but NSA allows firms to coordinate on investments regarding their network infrastructure, but not regarding any other aspects of their commercial conduct such as pricing or product offerings. So the NSA is much more limited in scope and the aim is to coordinate some of the sharing partners' investment into infrastructure with an effort to reduce cost, that may contribute to offer cheaper services to consumers.

Bourreau and Jullien [2018a] also argued for that NSA, which leads to coordination of investment, but not pricing decisions, should be seen more positively than mergers, since there is no harmful price coordination.

Coopetition

From industrial organization approach Brandenburg, Nalebuff [1997] name NSA-like cases as a **coopetition**, a parallel cooperation and competition at the same time. Coopetition combines the advantages of both competition and cooperation into a new dynamic business model, which can be used for not only generate more profits, but also to change the nature of the business environment. With other words it is a cooperation in creating value, and a competition in dividing it up simultaneously.

In NSA there is a technology production (mobile network services) cooperation and there is fierce competition at end-user retail mobile telecommunication market.

Co-investment

The new European Electronic Communications Code (“Code” or EECC) introduced in 2018 new regulatory provisions to stimulate investment in VHCN and help to achieve the Gigabit Society targets for EU. One of the key new provisions is **co-investment** for VHCN, that is an exchange for regulatory flexibility compared to standard access remedies. Originally it is used for fixed network investments, but it is also relevant for mobile, in which mobile network sharing among competitors is typical co-investment. In case of co-investments more operators make together the network rollout and there is certain pricing method for fair cost and benefit sharing.

European MNOs standpoints related to cooperation

ETNO disclosed in 2021 a joint statement of 13 CEO’s of European MNOs on requesting room for building scale in the telecom industry (ETNO [2021]). Vodafone CEO, Nick Read also added the European mobile market is “**hyper fragmented**”, and not only “**cooperation**” (interpreted: network sharing), but also “**consolidation**” (interpreted: merger) needed, especially on those highly competitive market (Italy, Spain, Portugal, UK), where all MNOs are “suffering” from profitability point of view.

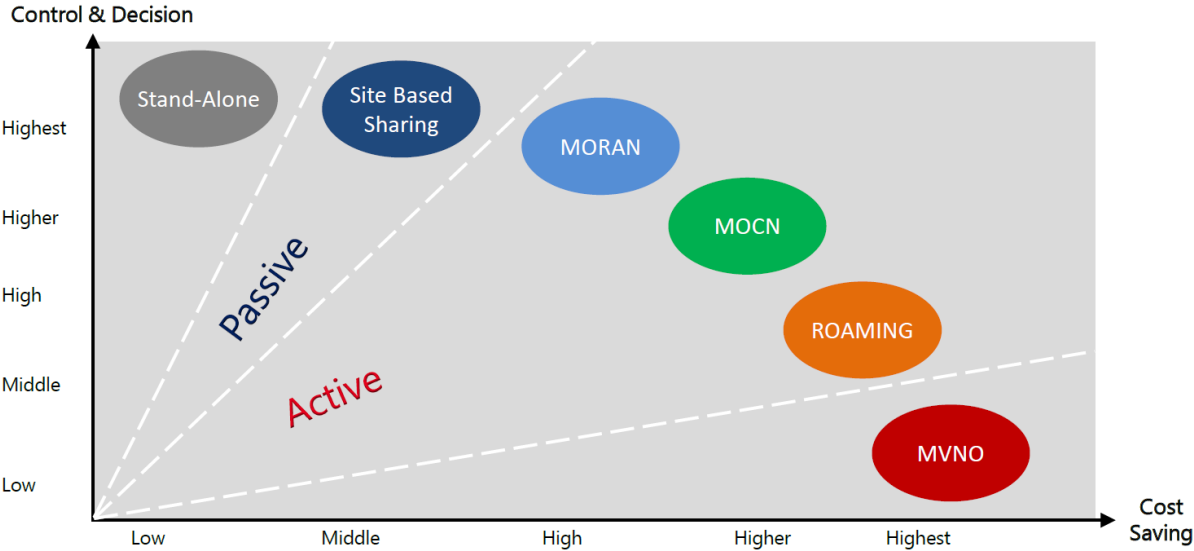
ETNO also announced an Analysys Mason research, that showed the European market fragmentation in terms of mobile service revenue per MNO group compared to US, South Korea and Japan, where top 4 MNO groups control more than 95% of revenue, while in Europe less than 60% (ETNO [2022]). Vodafone CEO declared that in Europe, the average customer base 4 million customer per MNO is, compared to US 100 million.

GSMA also distributed a study on Mobile market structure as well as financial and non-financial performance in the 4G area (GSMA [2020]). Key findings of the study were that markets with more concentrated market structures were able to deploy 4G more quickly and were better in network quality, like download speeds. The main comparison baseline was three or four player market and it stood out that in three-player market EBITDA margins and the CAPEX intensity (CAPEX/Sales) are higher, but both prices and ARPUs are quite similar as in the four-player markets. Currently it is considerably significant discussion whether and how to get from a four-player market to three due to market consolidation ambitions and in what structure to deploy 5G to reach high-performing networks in Europe.

Cooperation levels related to network sharing types

As described in the introduction several types of NSAs are existing. Huawei provided a good overview on key NSA types that presented in Figure 1.

Figure 1: Overview on Network Sharing related cooperation forms

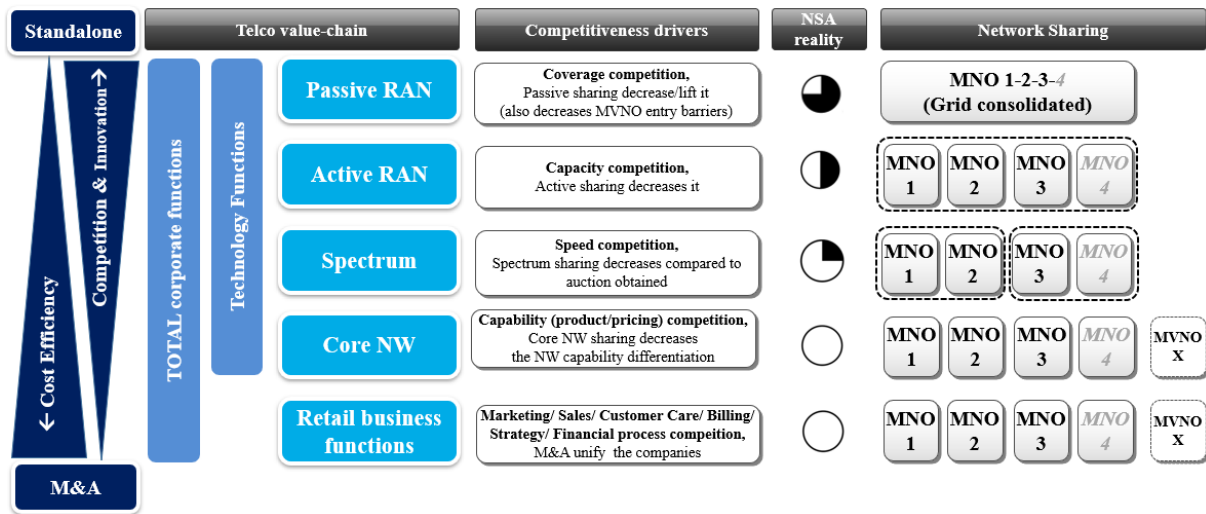


Source: Huawei [2020]

Figure one shows in case of different types of NSAs how the independent control and decision making decreasing and parallel the level of cooperation increasing, which may result higher cost savings.

If we are speaking infrastructure owner MNOs, then after passive and active (MORAN, MOCN, national roaming) sharing, the full merge is the final stage of cooperation, as drawn in Figure 2.

Figure 2: Overview on NSA related horizontal agreement milestones to M&A



Source: Földes [2021]

The higher the horizontal agreement scope, the closer the horizontal merger and acquisition (M&A) case that represents the highest cost efficiency but may soften competition.

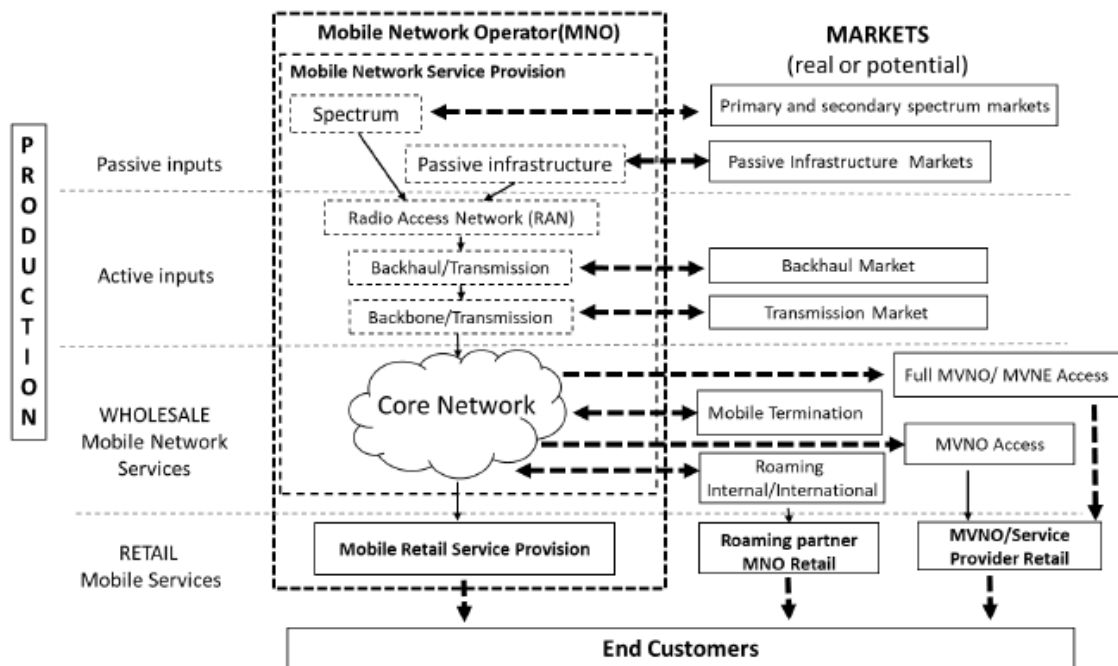
This was the case in Denmark, when Telenor and Telia signed an MOCN NSA (including active and spectrum sharing) and the whole network with spectrum was spin-off into a common JV in 2011. Later mother companies decided to fully merge their subsidiaries operation to exploit completely the savings opportunities, but finally they withdraw the M&A initiative in the face of the conditions imposed by the European Commission and run their business under NSA, creating the highest shareholder value based on cost-benefit analysis.

Telecommunication value-chain and market structure

The aim of this section that based on literature review highlight two key aspects of telecommunication value-chain that is essential to consider to later research findings. First, market structure is observed with upstream and downstream market focuses, secondly the role of network domains within technology production layer (upstream market) is analyzed from competition, in particular from differentiation perspective. Base on the findings, the relevant market is defined from competition policy point of view.

The vertical dimensions of mobile telecommunication markets are represented by Pápai *et al.* [2018] on Figure 3.

Figure 3: Overview on vertical dimensions of mobile telecommunication markets



Source: Pápai et al. [2018]

Pápai identified the following three layers, as production layer, wholesale layer and retail layer. Production layer contains the network technology as a service, which is sold by wholesale either to own retail internal end customers or via Mobile Virtual Network Operator (MVNO), as a wholesale partner to third party end customers. This logic is in line with the accounting separation principles, imposed as an obligation for operators identified with Significant Market Power (SMP). Real, operational separation also exists with different stages (Cave [2006]) that becomes reality with asset reconfiguration (spinoff) to tower companies (TowerCos) or fiber companies (FiberCOs), that provides wholesale services to both internal and external customers.

Therefore, the network technology market becomes a functional **upstream market** and the retail market is a **downstream market**. Mobile Network Sharing Agreements, as a horizontal production agreement impacts the production upstream market. Competition at the upstream market is a precondition for competition in the downstream market, thus the proper understating of the potential anti-competitive impacts of NSA is necessary to make full evaluation of network sharing.

Network technology production in upstream market consist of Radio Access Network (**RAN** – e.g., base station, towers), Transmission (TRM, mainly has an access part and core part) and

Core Network, which is the intelligent part of the network. RAN has passive and active parts as described in the introduction already. Mobile Network Sharing Agreements impact only the RAN and the access TRM parts of the network in line with the type of NSA: passive element related, active element related (MORAN or MOCN with spectrum sharing). As can be seen in Figure 2. the NSA has different competition constraining impacts in RAN segment. In case of passive sharing the coverage related competition decreased, as same locations are used, and in case of active sharing due to same radio assets are used, the capacity differences might be decreased. Important note, that only RAN production part of network technology upstream market is affected, the Core part remains fully independent. The core network as the intelligent part of networks, allows MNOs to identify their own product, service and pricing capabilities. In matured mobile telecommunication with 99% population coverage, the **differentiation** has already moved from coverage and even from capacity to product and service capabilities. So NSAs do not eliminate upstream market competition and differentiation, just only reduce in terms of coverage and capacity, but remains unchanged in product and service differentiating core network.

Summing up, in total telecommunication value chain only RAN part of network production upstream market impacted by NSAs, and the Core not and even all other downstream retail functions like marketing, sales, customer care, billing, IT, and overhead (corporate strategy, corporate governance, public relation) are independent as NSA is only a horizontal production agreement and not a full horizontal merge, as discussed above.

For competition evaluation the **relevant market** has to be determined, where from supply aspect the substitution is limited, and from demand side it is without choice if a certain type of service is needed. In this research paper the relevant market will be the retail telecommunication service market at national levels at the EU, containing both voice and data, as well as consumer (prepaid and postpaid included) and business customers after 2014 to nowadays. In spite of unified relevant market assessed, in some cases a special focus will be taken to the market divers like smartphone data usage (Small Screen Internet - SSI), as current OPEX&CAPEX spending predicted to be data volume driven.

Competition – innovation – investments

Competition policy put a particular emphasis on promoting competition and innovation, however there is no linear relationship between them. A large number of researches have

attempted to determine it and the first serious discussions and analyses emerged during the 1940s with Schumpeter, later followed by Arrow and Aghion.

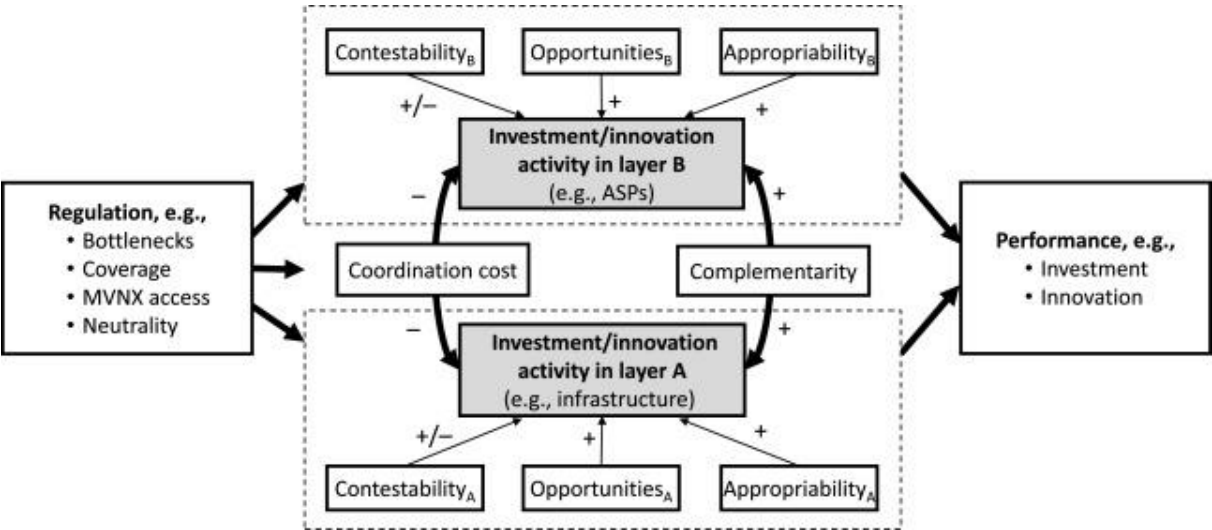
Schumpeter found that innovation leads to higher margins and therefore a monopolist has more incentive to invest than a firm in a competitive market, as the monopolist seeks to maintain its market leading position (Schumpeter [1942]).

In contrast to that Arrow showed that incentives to innovate can be stronger in competitive markets as firms facing competition seeks to innovate, to gain market share from its competitors and improve its margin, whereas a monopolist would mainly cannibalize its own sales (Arrow [1962]).

The theoretical and empirical literature has carried on the debate about whether there is likely to be more innovation under conditions of monopoly or competition. Aghion reconciled these standpoints to a degree by demonstrating that the relationship between the level of competition and extent of innovation appears to be inverted-U-shaped. (Aghion [2005])

Despite of the open debate on the relationship (in terms of both strengths and shape) in the latest literature Bauer and Bohlin summarized the key-levers of competition, innovation and investments as shown in Figure 4.

Figure 4: Overview on key-levers of investments



Source: Bauer, Bohlin [2022]

The established assessment framework consists of the competitive conditions (“contestability”), the technological and economic capabilities (“opportunities”), and the

conditions for the rewards for taking the innovation risk (“appropriation”) (Bauer, Bohlin [2022]). In each of the network layers described above, innovation is driven by the contestability of the market, the opportunities for innovation, and the appropriability conditions. Bauer-Bohlin carried out an example that innovations in network layer to deployment a broader range of functional capabilities will likely expand the innovation opportunities in the next layers build to that (like applications). Innovation theory refers that economic, technical, and regulatory innovation opportunities will be positively related to overall innovation activity. (Bauer, Bohlin [2022])

2.2. Regulatory framework

The Mobile Network Sharing Agreements are regulated via telecommunication sector and competition regulation. At first the telecommunication, then the competition legal milestones of EU will be scrutinized from NSA approval point of view.

Sector regulation

The sector regulation contains network sharing specific direct regulations and overall indirect legal baselines, providing for NSA adaptable relevant principles.

NSA related direct sector regulation

The direct regulation elements are the OECD guideline on Wireless Market Structures and Network Sharing (OECD [2014]), BEREC report on infrastructure sharing (BEREC [2018]) and BEREC Common position on infrastructure sharing (BEREC [2019]).

The OECD report analysis the advantages and disadvantages of network sharing both from the operators’ and the consumers’ perspective. The report makes use of competition policy categorizations of potential anticompetitive behavior and distinguishes between potential unilateral and coordinated effects of infrastructure sharing agreements. Regarding final recommendation, it is hard to conclude whether the benefits are likely to dominate the costs, or whether the reverse is valid.

The BEREC report from 2018 summarize the results of the NSA related questionnaire of BEREC sent to NRAs in the EU to obtain an overview on current status.

The BEREC common position from 2019 principally assess the feasibility of infrastructure-based competition and refers to the population density of the areas, as the main criterion to decide whether infrastructure-based competition is feasible in an area or not. Based on that identifies three most typical combinations:

1. High density urban areas, where full infrastructure-based competition is feasible.
2. Mid density suburban areas, where feasibility of infrastructure-based competition is not predestined.
3. Low density rural areas, where infrastructure-based competition is not rationally feasible.

Based on BEREC Common Position, in the first type of areas passive NSA is welcome, but active network sharing may be restricted, as it may substitute the infrastructure-based competition, which is the preferred form of competition.

In the second type of area, there is some degree of infrastructure-based competition, so active sharing should be assessed on a case-by-case basis.

In the third type of area, infrastructure-based competition would not be feasible so active network sharing would not only allowed, but should be encouraged to enable all operators to carry-out. Indeed, in these areas without network sharing, competition is unlikely to emerge.

BEREC's position seems to **distinguish between active and passive sharing**. As pointed out earlier, passive sharing is seen as permissible in all areas and "active sharing [...] can achieve greater savings than passive sharing." Maier-Rigaud *et al.* [2020] argues that this position may come from that, shared rollout is better for consumers, than no rollout at all. The BEREC common position necessarily excludes the possibility of active sharing increases consumer welfare compared to independent networks. Instead of assessing possible trade-offs between procompetitive and anticompetitive effects of network sharing, it is assumed that beneficial effects of NSAs are clear in less densely populated areas, but alleged harmful effects in more densely populated areas. So as the population density increases in a given area, the anticompetitive effects are likely to outweigh the cost reduction effect. The study of Maier-Rigaud *et al.* conducts that the relevant question might be not whether a network exists or not, but whether under active NSA consumers gets better service or not. Thus, the combination of prices and quality to customers is the key to assess whether NSA has beneficial effects or not.

NSA related indirect sector regulation

The Framework directive (Directive 2002/21/EC, the “original Code”) allows the imposition of sharing of property and passive infrastructure in operators’ networks. The Commission Recommendation 2010/572/EU (“NGA recommendation”) already states that in certain conditions, co-investment for fixed infrastructure may lead to effective competition in a certain area. The Directive 2014/61/EU (“Broadband Cost Reduction Directive”) contains that in imposing access obligations, NRAs should - among other factors - take existing co-investment offers into account. Finally, the European Electronic Communication Code of 2018 (“EECC” or “new Code”) in Article 76 provides that SMP remedies shall not be imposed, if co-investment agreements meet the criteria set out, so EC introduced positive incentives for co-investment. Article 61.4 states that NRAs may impose the sharing of (passive and even active) infrastructure using mobile spectrum, but only under certain conditions, when the sharing is inevitable. In Article 47 conditions for radio spectrum rights of use are set that provide for the possibility of passive or active sharing, commercial roaming, or joint roll-out of infrastructure. Sharing of radio spectrum shall not be ruled out in these conditions.

Overview on current NRA practices

In each EU member states most of the NRAs issued some kind of regulation related to NSA approvals. Passive sharing principally supported, Actives sharing case by case assessed, spectrum or even core network sharing generally not supported (with a few exemptions in spectrum: Denmark, Sweden, Finland, Poland and partially in Hungary), as it may soften the competition in network function and it may bring closer a full horizontal merger case.

It is essential to call the attention, that although Mobile Network sharing can be imposed by NRAs in the EU in market review process for SMP operators, the regulators not use this opportunity and NSAs are vast major commercial driven.

One of the most detailed guidelines published by ARCEP, the French NRA already in 2016 (ARCEP [2016]) that is a predecessor of BEREC Common Position from 2019 and provided the principals for EU wide regulation. NMHH, the Hungarian NRA issued the NSA related regulation in 2020 in frame of secondary spectrum trading following the ARCEP and BEREC Common Position, however not exclude principally the spectrum sharing opportunity acknowledging the potential technology benefits for customers.

Competition regulation

The competition law based on the **Article 101 of the Treaty on the Functioning of the European Union (“TFEU”) to regulate cooperation agreements**. It focuses first on whether the cooperation has an anticompetitive effect. Article 101(1) TFEU prohibits agreements that have as their object or effect the prevention, restriction or distortion of competition within the internal market. However, Article 101(3) allows for an exemption, where the restriction of competition is kept to the minimum necessary and is compensated by the promotion of technical or economic progress, while allowing consumers a fair share of the resulting benefit. The exemption under Article 101(3) translates into a multi-factor balancing test. (TFEU [2008]) The prohibition applies both for vertical and horizontal agreements, like NSAs.

Article 102 of TFEU regulates the abuse of dominance by one or more undertakings of a dominant position within the internal market or in a substantial part of it shall be prohibited as it may affect trade between Member States. Prohibited abuse may consists *(i)* directly or indirectly imposing unfair prices (purchase or selling) or other unfair trading conditions; *(ii)* limiting production, markets or technical development; *(iii)* applying different conditions to equivalent transactions with other trading parties, causing a competitive disadvantage.

The fact that a corporate holds a dominant position is not in itself contrary to EU competition rules, just when the behavior refers to abusing with it. A dominant undertaking has a “special responsibility” not to engage in conduct that may distort competition. Article 102 prohibits the abuse of individual and collective dominance. The first step in the assessment of market power is the relevant market definition, that determines the boundaries of competition between firms, both in terms of products/services that they supply and geographic areas where they operate, to calculate its market share or consider the potential of new entry. The process of defining a relevant market begins by establishing the closest demand-side substitutes to the product/service on which the investigation focuses.

Contrary to article 101 TFEU, article 102 does not explicitly require that an abuse of dominance has an anticompetitive effect.

The **EC issued a guideline on the applicability of the Article 101 TFEU** on how to apply for horizontal cooperation agreements (TFEU European Commission Guideline [2011]). Although guideline do not refer explicitly to telecommunications agreements, it is the most important references for National Competition Authorities (NCAs) when they assess NSAs.

The production agreements related part of the guideline is particularly relevant for NSA evaluation and Bourreau *et al.* from Centre of Regulation in Europe (CERRE) highlights the following potential competition restrictions from the guideline (Bourreau *et al.* [2020b]).

- Point 158: Coordination of the participants' competitive conduct as suppliers may lead to higher prices or decreased output, product quality, product variety or innovation.
- Point 159: Anti-competitive foreclosure of third parties may take place in a related market. Participants may use their joint production to raise the costs of the middle product necessary to downstream competition, that ultimately may force the rival to leave the market.
- Point 178-179: Commonality of costs may increase the risk of a collusive outcome, if production costs are a large proportion of the variable costs. This may weaken competition at downstream market and may lead to higher final prices.
- Point 183: Anticompetitive aspects of the cooperation are limited and outweighed by efficiency gains, from which consumers may obtain a fair share.

Regarding efficiency gains Bourreau *et al.* conducts, that production agreement might be procompetitive if it provides efficiency gains in the form of cost savings or better network quality. By producing together corporates may save costs that otherwise were duplicated. NSA participants can also produce at lower costs, if the co-operation enables them to increase production (economies of scale). Producing jointly can also help companies to improve product quality by putting together their comparative advantages (skills and know-how). Co-operation may enable companies to enhance product variety, which they could not have reached otherwise. Co-production also may allow participants to increase the number of different types of products that may provide cost savings (economies of scope).

To assess each case of horizontal cooperation, it must be analyzed case by case in terms of the market shares of the parties, the geographic scope of cooperation, which parts of the network are shared and what information will be exchanged between the parties. RAN Sharing may lead to different levels of coordination depending on the sharing scope, active sharing creates a greater risk for anticompetitive coordination than passive sharing, therefore poses a greater threat to competition. This is due to each participant's technical independence and capacity for differentiation decreased, when active elements were shared. Parties have to coordinate and exchange information on upgrades and data traffic planning. In contrast to passive NSAs, where each participant preserves its autonomy in network characteristics.

The EC launched a public consultation on the **draft revised Horizontal Block Exemption Regulations and Horizontal Guidelines** (TFEU European Commission revision [2022]), which for the first time has a special guidance under chapter 3.6 for Mobile infrastructure sharing agreements, “as a specific illustration of production agreements where services are involved”. Horizontal cooperation may lead to substantial economic and sustainability benefits, including support for the digital and green transition. The proposed revised rules aim to keep up with developments so that beneficial cooperation can take place, for example when it comes to sustainability or data sharing. The new consultation guidelines seem to consolidate previous recommendations.

Benefits are cost reductions, quality improvements, emergence of competition that would not otherwise exist, achieving large efficient networks “without the need for consolidation through mergers”. Mainly mobile network sharing agreements do not have an anticompetitive object but they may have anticompetitive effects, like reduction of infrastructure competition or reduction of the sharing parties’ decision-making independence. Passive RAN sharing considered as it “unlikely” to give rise to restrictive effects on competition, Active RAN sharing agreements “may be more likely” to give rise to restrictive effects on competition and spectrum sharing (or spectrum pooling) is a more far-reaching form of cooperation and “may restrict” the parties’ ability to differentiate their retail and/or wholesale offers even further and directly limit competition between them.

The draft guidance concludes a certain minimum condition that a mobile network sharing agreement would need to meet to be considered “prima facie unproblematic” under article 101 TFEU. Operators control and operate their own core networks, unilaterally deploying, upgrading and innovating their networks. Operators maintain independent retail and wholesale operations, and do not exchange more information than what is strictly necessary, and they put in place “Chinese walls”.

2.3. NSA related procompetitive, anticompetitive effects, netting and recommendations

In the last part of literature review the Mobile Network Sharing Agreement relevant main benefits, drawbacks and a potential netting are summarized. Recommendations for more likely approval from regulators will be concluded also.

Procompetitive effects (benefits)

NSA related benefits for social welfare are listed both in OECD [2014] and BEREC [2019] Common Position guidelines that summarized in Table 3. below.

Table 3. Overview on NSA procompetitive effects

#	Benefit	Main elements
1.	Improved Network Efficiency	Sharing leads to faster and wider rollout of high-speed networks coverage and higher quality.
2.	Cost reduction and efficiency gain pass through consumers	Sharing of deployment costs, sharing of operational costs, leading to lower prices.
3.	Enhanced customer choice	Enhanced competition, benefiting customers in terms of lower prices and facilitate entry for third-party operators.
4.	Environmental benefits	Single infrastructure, with less impact on environment.

Source: Author's summary on OECD [2014], BEREC [2019], Bourreau et al. [2020b] and Maier-Rigaud et al. [2020]

Infrastructure sharing may **decrease fixed costs (CAPEX)** of network rollout or upgrade. Cost-sharing for deployment costs, synergies, and gains from coordination may contribute to faster and wider coverage and higher quality. These cost savings are beneficial for consumers when they translated into higher investment. Investments have two main forms. Firstly, operators may invest in expanding the network coverage. This is particularly relevant for fixed (e.g., new fiber access deployment) and mobile (e.g., 5G) networks. Secondly, MNOs can invest in higher network quality (e.g., higher capacity and data speeds), when they densify their mobile networks.

Infrastructure sharing may also **shrink variable costs (OPEX)** of maintaining and operating the network. Consumers benefit from the reduction of variable costs if fair share passed through in terms of lower prices that may also incentivize competitor(s) to reduce prices because of “umbrella effects” (Inderst *et al.* [2014]). (e.g., if pricing strategy follows price to market

principle). The level of access or transfer price within the NSA is essential to stimulate service-based competition, benefiting consumers in terms of lower prices and wider choice of service providers in those areas where competition would be limited otherwise.

The NSA might contribute to facilitate entry of third-party operators by permitting them to offer broad coverage and services from the outset while they deploy their own infrastructure.

NSAs correspond to the environmental expectation of having a single infrastructure rather than multiple ones that benefit can also be an aspect of “public interest”.

Anticompetitive effects (drawbacks)

The discussion on potential anticompetitive effects of NSA follows the structure of BEREC Common Position [2019] and OECD [2014].

BEREC lists three potential drawbacks of infrastructure sharing, as (i) reduced incentives to invest and ability to compete; (ii) increased coordination between participants and (iii) reduced network resilience.

The OECD report applies a more complex approach and distinguishes between potential unilateral (non-coordinated) and proc-collusive (coordinated) effects of infrastructure sharing agreements.

Anticompetitive effect summarized in Table 4.

Table 4. Overview on NSA anticompetitive effects

#	Drawback	Main elements
<i>Unilateral (non-coordinated) effects</i>		
1.	Reduced incentive for investment	Shorten incentives for unilateral investment or hold-up strategies resulting in lower total network investment.

#	Drawback	Main elements
2.	Decreased differentiation	Constrained for differentiation from co-investment partner, unilateral investment, service innovation and other independent strategies;
3.	Excessive access or transfer pricing	Raising internal and/or external access prices to soften competition and raise final prices at the downstream (retail) market
4.	Incentive for foreclosure	Raise market entry barriers by excluding third-party potential rivals with deterring access conditions (e.g., prohibitive, excessive access prices, too high commitments). In case of MVNOs, it is vertical impact also.
5.	Cost disadvantages	Outlayer competitor might face to a cost disadvantage, weakening its competitive position, (but any investment in coverage or quality has this effect, is a normal feature of competitive dynamics)
6.	Deter late co-investments	Cherry-pick from third parties, deter late co-investments.
<i>Pro-collusive (coordinated)</i>		
7.	Explicit collusion	Potential explicit collusion, depending on the possibilities to exchange information and to coordinate on more than joint investment required.
8.	Tacit collusion	Potential tacit collusion depending on partners' ability to: coordinate on a collusive 'agreement', detect deviations from the agreement and punish deviations.

#	Drawback	Main elements
<i>General</i>		
9.	Network supply security	Network resilience: a single rather than multiple infrastructures may imply that in case of network fault, consumers cannot switch to another network.

Source: Author's summary on OECD [2014], BEREC [2019], Bourreau et al. [2020b] and Pápai et al. [2018]

Regarding unilateral anticompetitive effects several aspects assessed in the literatures.

Bourreau *et al.* [2020b] indicated that co-investors may have the ability and the incentive to raise final price and soften competition at the retail level by setting **high access or transfer prices** for shared infrastructure and to foreclose potential competitors from using their joint network (e.g., asking prohibitive access prices to outlayers), which would be of course, harmful for consumers. NSA allows for participants to benefit from cost reductions, but if some other operators not allowed to enter into the agreement, that may lead to a cost disadvantage, weakening their competitive position.

Investment incentive reduction might have “spill over” effect, if one partner reduces the investment (in terms of coverage or quality) and the other partner follow-it. Due to this externality, partners may under-invest compared to a counterfactual with independent investment. If investment incentives between the parties are not aligned, one of the parties may be able to hold back the others, slowing the others’ pace of investment. If there is uncertainty about the profitability of investment, potential co-investors may have the incentive to wait until sufficient information becomes available, thus reducing investment incentives in the first place.

Several significant concerns raised related to pro-collusive (non-coordinated) effects in the literature also.

Based on Bourreau *et al.* [2020b], **increased coordination (information exchange)** between co-investors at the network level (e.g., investment plans), may facilitate coordination in other dimensions (e.g., prices or quantities), thus pose a risk of (tacit or explicit) collusion between

partners. They could also coordinate their technological choices, opting for lower network quality, or reduce investment, thereby increasing profits.

By sharing infrastructure, operators may end up with a **very similar cost structure (“cost commonality”)**, which is expected to facilitate tacit collusion. Pápai *et al.* [2018] shows that variable costs opposed compared to fixed costs, when discussing cost commonality, because economic theory shows that fixed costs do not influence pricing. The majority of network costs would normally be considered fixed that become variable (e.g., traffic based) in NSA, that may impact retail pricing also. However in reality, industry has to recover and return fixed costs to get better market valuation, so purely variable (marginal) cost pricing is not realistic, fixed cost based depreciation or even cost of capital (WACC) have to covered also.

Related to **collusion and R&D Joint Ventures (RJV)** considerable amount literature exists.

Lambertini *et al.* [2002] focused on product innovations and considered that RJVs result in identical products for the participating firms. By restricting firms’ ability to differentiate their products and forcing them to compete more directly. It suggested that the effect of infrastructure sharing on the likelihood of tacit collusion depends on how NSA affects firms’ costs and product differentiation.

Miyagiwa [2009] showed that an R&D joint venture facilitates collusion (compared to a benchmark situation with independent R&D) as symmetry makes collusion more likely to emerge.

Krämer and Vogelsang (2017) ran an empirical experiment to assess collusion in infrastructure sharing agreements with telecommunication context. They found that network investment related communication facilitated a collusion at retail level, but did not lead to more investment.

Sovinsky and Helland [2018] provided empirical evidence that R&D joint ventures can serve a collusive function. They showed that the revision of antitrust rules in the 1990s in the US to decrease collusive agreements, was followed by a significantly reduced joining, therefore it highlights that coordination in R&D dimension may facilitate coordination in other dimensions.

Overall, Bourreau *et al.* [2018a] found that collusion may involve a trade-off from a social point of view between static efficiency and investment incentives. On one hand, collusion leads to higher prices, and thus, lowers consumer welfare; but on the other hand, participants make larger profits, which may enhance their investment incentives.

Net impact review of pro- and anticompetitive effects

Although Article 101(3) makes an exemption under prohibition of market distorting horizontal agreements, if technical or economic benefits outweigh potential harms, it is difficult to assess at theoretical level the net effect of NSAs.

More conclusive assessment of infrastructure sharing's net effect on competition and investment, discussed at micro economic level by Bourreau *et al.* [2018a].

Bourreau *et al.* proposes for **fixed infrastructure sharing** a game-theoretic model to decide on how much to invest in a new network infrastructure by an MNO. The investment decision is a coverage decision in fixed network, the MNO decides which areas of the country to cover by fiber, with some areas being cheap ("black" areas) to cover, while others ("grey" or "white" areas) involve increasingly high deployment costs. The finding is that, compared to a standard access obligation, co-investment increases investment in network coverage and leads to lower prices for consumers in the areas with service-based competition.

There is one empirical paper that indicates the effect of co-investment on investment and competition. Aimene *et al.* [2021] used data on the deployment of FTTH and co-investment in French municipalities in the period 2015-2018 and evaluated the impact of the French model for co-investment (mandatory one-way access). Co-investment is associated with a higher take-up for FTTH services and leads to stronger service-based competition in co-investment areas (when co-investment occurred, the market share of the incumbent operator, Orange, decreased by 5.8%). These empirical findings seem consistent with micro-economic analysis of Bourreau *et al.*

Mobile Network Sharing slightly differ from fixed co-investments, as it is not only new rollout related (e.g., 5G), but for the upgrade of existing infrastructure. Mainly there is no access obligation, most mobile markets has 3 or 4 nationwide networks, and in case of the absence of sharing, some (if not all) of MNOs would invest independently to upgrade their networks.

Motta and Tarantino [2017] studied the impact of a network sharing agreement between two (mobile) operators on prices and investment in an oligopolistic mobile market. They analysed the incentives to invest in cost-reducing innovations: coordinate their investment while competing in prices. They found that without merger's investment synergies, a horizontal merger reduces consumer welfare. If synergies are sufficiently large, consumers benefit, as

network sharing agreement leads to lower prices and higher investment, and therefore increases consumer surplus.

Maier-Rigaud *et al.* [2020] provided empirical evidence on price and investment (quality) impact of the 4G NSA in the Czech Republic. First, with difference-in-differences approach they found that the network sharing agreement led to a reduction of prices in the Czech Republic compared to a control group of other European countries. Second, based on a structural model of demand and supply for mobile services, they reported that network sharing has led to not only lower costs, but also to increased network quality. (more details of the case discussed in fifth chapter).

Recommendation for NSA design

What emerges from the literature review is the necessity a list of recommendation for Mobile network sharing design that increase chance of approvals from regulators. Based on Bourreau *et al.* [2020b] the following Table 5. presents the key recommendation for sharing design.

Table 5. Overview on key recommendations for NSA design

#	Recommendation	Main elements
1.	Proven efficiency gains and social benefits	Undertake more and faster total network roll-out, or upgrades, share efficiency gains.
2.	Transparent and cost based access or transfer pricing	Do not set prices at excessive level, as it may lead to raising retail prices and softening competition or foreclose competitors.
3.	Keeping strategic independence	Guarantee freedom for strategic decisions (e.g., unilateral (own-used) network investment, service and product design, pricing, quality parameters) of each partner.
4.	Keeping wholesale independence	Allow for each partner to offer wholesale access to the shared infrastructure, individually and independently.

#	Recommendation	Main elements
5.	Extension of cooperation with newcomers	Keep at minimum level the exclusivity provisions for entering the agreement; but protect co-investment against opportunism from late co-investors.
6.	Minimized coordinated behavior	Keep information exchange at the minimum necessary level, and pre-determine termination rules in details and explicit.
7.	Appropriate Operational model	Prefer contractual arrangements (e.g., reciprocal access or one-way sharing), that may facilitate less market distortion, than cooperative arrangements (e.g., joint ventures).
8.	Limited Geographic scope	Limit geographic scope to create fewer competition concerns, than sharing large parts of a country. Share in rural areas that may create fewer concerns, than sharing in urban areas.
9.	Limited Technical scope	Share Passive RAN that raises fewer competition concerns, than active RAN sharing.

Source: Author's summary based on Bourreau et al. [2020b]

Regarding to the list of recommendations one important complementary argumentation is discussed by Bourreau *et al.* [2020b]. **Operational model type** is such an implementation detail that also may impact the acceptance of NSA. Joint venture model allows joint control of the infrastructure and it is a high degree of coordination. The one-way sharing is a very low degree of coordination between firms, since the infrastructure is owned and controlled by the investing operator. Reciprocal access is in between these two cases: each operator controls its own infrastructure, but there may be some coordination between partners (e.g., geo split - their respective exclusive territories). This a trade-off from both firms and society.

From Participants' benefit side the cooperative agreements (joint ventures) has more synergies, commitments and less risk of opportunistic behavior from partner. In favor of contractual agreements (reciprocal access, one-way sharing) comes lower transactions cost, more flexibility and more incentive to apply own "know-how" for the shared infrastructure.

From Societies' benefit side the cooperative arrangements may results more investments if there are strong investment "spillovers". In favor of contractual agreements comes more investments if there are weak investment "spillovers" and less risk for unilateral or coordinated anticompetitive effects.

These literature review based aspects will be applied in fifth section for assessing the Hungarian and Czech Mobile network sharing agreements after research methodology conducted in third section and NSAs related basic information outlined in fourth chapter.

3. Research methodology

The **research aim** of this paper to quantify, measure and assess mobile network sharing related procompetitive and anticompetitive effects. Table 6. covers selected items that has clear measures to assess impact on competition, innovation and social welfare.

Table 6. Overview on NSA effects related Measures

#	Benefit/Drawback	Measures
Procompetitive effects assessment		
1.	Improved Network Efficiency	4G and 5G related: Coverage, Penetration, Used Capacity (monthly average data traffic per subscriber), Speed
2.	Cost reduction and efficiency gain pass through consumers	Unit cost decrease and fair share pass through to retail prices (bucket view)
Anticompetitive effects assessment		
3.	Excessive access or transfer pricing, incentive for foreclosure	Cost based and open transfer prices, 3 rd party partnerships
4.	Market context and cost disadvantages	Market context impact: market concentration, market share (voice subscriber, data traffic and service revenue based). Revenue based profitability (EBITDA/Sales)
5.	Decreased incentive for competition (differentiation), incentive for collusion	Different market strategies and offers
6.	Reduced incentive for investment	CAPEX intensity (CAPEX/Sales) – limited accessibility

Source: Author's summary

In the fifth, assessment section these measures are evaluated for Czech Republic (CZ) and Hungary (HU) for 2014-2021 period. First the current status (2021 H1) is analyzed in comparison to each other and other European benchmark data then if relevant, the trend data are interpreted.

From methodological point of view there is a **difficulty in how to assess improvement**, which is requested to evaluate net impact of NSAs in line with TFEU Article 101(3) part, whether potential benefits outweigh potential harms, or at least there is a relative change to net positive direction. Improvement should be in a comparison to such peer markets, where no NSA or any bigger market changes (e.g., new, disruptive entrant or exit) took place. The potential peer markets should come from EU countries, especially from CEE region, however under similar economic conditions difficult to find a “traditional” telco market without some extent of mobile network sharing or TowerCo spinoffs. Therefore, besides CZ and HU comparison, EU 27 and CEE data are used as a reference peer data for assessment of relative changes. So, the interpretation of the findings will be for a stagnating position, that the relative ranking has not changed, the assessed market has a similar progression rate as the reference peer group. It does not mean, that there is no improvement, it just means, there was normal improvement. If the relative ranking improves, it means that the assessed market overimproved the average of peer markets, so it is definite benefit. If the relative position worsened, it means the assess market lagged behind.

This study employs quantitative empirical data based approach both for primary and secondary data analysis. The research design contains conclusive researches, in both descriptive and causal approaches. Descriptive research with cross-sectional design and in some cases also with longitudinal design applied for all measures related to network quality and market context description. The hypothesis on competition distortion impact of NSAs in retail mobile service market analyzed via retail market share trend.

Causal research is limited to representative sample analysis, as not enough reliable data (observations) are available for correlation analysis of profitability and investment intensity neither for cross-sectional, nor for longitudinal design. The hypothesis on competition restriction impact of cost disadvantage is analyzed via EBITDA margin and CAPEX margin on available most suitable sample data.

Secondary research data are also displayed for market concentration and on CZ price as well as quality by difference in difference and structural model.

4. Discussion of Czech and Hungarian Mobile Network Sharing Agreements

This paper put into the center of analysis the Czech and Hungarian markets from CEE area, as these countries show high degree of similarities, as mobile market majored by the same European telco groups and regulatory assessment run into the same bottleneck. Although competition regulation and the European Commission raised potential serious concerns already in 2016, the cases have not yet been concluded, therefore NSAs have been in place in unchanged form for 8 years, so wider dataset is available to assess whether potential serious concerns distorted the market.

Table 7. shows the main characteristics of the CZ and HU mobile markets.

Table 7. Overview on CZ and HU mobile market

Dimensions (data for 2021 YE)	Czech Republic	Hungary
Territory	78,871 sq KM	93,030 sq KM
Population	10.52 Million	9.73 Million
GDP per capita (PPP based, in USD), 2020 YE <i>(EU27 avg: 44,791 USD – Worldbank)</i>	41,608 USD	33,076 USD
Total subscribers (active SIM cards) <i>(CZ: 2020 YE, HU: 2021 H1)</i>	12.99 Million	11.23 Million
TOP 3 MNOs and Market share <i>(subscriber based, active SIM) (HU and CZ: 2021 H1)</i>	1. T-Mobile (DT): 38.9% 2. O2 (PPF): 28.1% 3. Vodafone: 25.5%	1. Magyar Telekom (DT): 43.9% 2. Vodafone: 27.4% 3. Telenor/Yettel (PPF): 26.8%

Dimensions (data for 2021 YE)	Czech Republic	Hungary
Avg. Voice minutes (per active SIM, monthly) <i>(EU27 avg: 186 min – Statista.com)</i>	138 min	200 min
Avg. Data traffic (per data using active SIM, monthly) (HU and CZ: 2021 H1) <i>(CEE: 9.9 GB; Western EU: 15.5 GB – Ericsson)</i>	4.0 GB	7.2 GB

Source: Author's summary based on Worldbank [2020], CTU [2021], NMHH [2022], Ericsson Mobility Report [2021] data

The Czech Republic has higher population density and more developed compared to Hungary, however in Hungary both voice and data traffic usage is higher. Both markets a typical 3 MNO player market and currently operators belong to the same bigger European telecommunication groups. The MVNO market is more active in CZ, but almost insignificant in HU. Markets are matured, however slight changes took place, in HU Vodafone has grabbed the 2nd position based on more measures in recent years.

The markets' profitability is normal, the market leaders have stable 30-40% EBITDA/sales ratio, only the Vodafone Hungary operates with a margin slightly under 25%, originated from almost twenty years 3rd position on the market, and later overspent the market to reach the 2nd position. So, despite Vodafone holds in many terms the 2nd position, on the same profitability level probably it would be only the 3rd player, and this is important, as the Hungarian mobile network sharing agreement was signed by Magyar Telekom with 1st and Telenor with 2nd market positions.

Markets' investment is also in line with European telco trends. Integrated telcos due to fixed (fiber) rollout spend more, around 15% CAPEX/sales, while pure mobile operators invest less, CAPEX/Sales is just slightly above 10%, without special influences, like spectrum auction fees.

Summing-up, CZ and HU mobile markets operated under normal conditions w/o any bigger market impacts and market players also faced to data increase predictions that required to introduce cost efficient co-investments, like mobile network sharing.

Mobile network sharing agreements in CZ and HU

In Czech republic the market leader T-Mobile CZ (subsidiary of Deutsche Telekom) and second market player, integrated incumbent O2/Cetin (at that time owned by Telefonica, later bought by PPF Group; Cetin is a divested asset company both for fixed and mobile) signed a MORAN (passive + active asset sharing) NSA in 2011 for rural 3G 900 MHz rollout and operation. Later the cooperation was extended also 2G and 4G for the entire country with geo split, except two largest cities (Prague, Brno). Third Market player Vodafone was invited into talks initially, but later remained outside. The local NRA did not identify any competition risk in 2015, but in 2016 the European Commission launched an investigation.

In the Hungarian case the integrated incumbent market leader (both fixed and mobile) Magyar Telekom (subsidiary of Deutsche Telekom) entered into an MOCN (passive + active asset and spectrum sharing) NSA with second market player Telenor Hungary (at that time owned by Telenor Group, later sold to PPF Group) on 4G LTE 800MHz rollout in the whole country with geo split operation, except capital Budapest. The highest cost saving potential, but from regulatory aspects most opposed MOCN NSA concept might come from Telenor side related to Danish market, where Telenor Denmark and Telia Denmark had an approved MOCN NSA from 2012. Third market player Vodafone appealed the NSA at NCA. Local NRA approved the agreement driven by technology spectrum efficiency aspects, however local NCA raised concerns in 2015, but final decision not made till nowadays. This resulted, that no further NSA made in the market, however 5G non-standalone rollout started with 2-4G lifecycle network swap in separated 3 networks, apart from the only shared 4G L800 MHz layer.

Table 8. summarize the main characteristics of the CZ and HU NSAs.

Table 8. Overview on NSAs of CZ and HU

#	Dimensions	Czech Republic	Hungary
1.	Technology domains	MORAN (passive + active asset sharing)	MOCN (passive + active asset + spectrum sharing)
2.	Spectrum bands	N/A	4G 800 MHz – rural coverage spectrum (temporary 3G 900MHz - rural coverage spectrum)

#	Dimensions	Czech Republic	Hungary
3.	Technology generations	3G, later 2G-3G-4G, no 5G extension	4G (temporary 3G), no 5G extension
4.	Areas	Population coverage: 85% Geosplit: rural, later T-Mobile (West), O2 (East), exemption: Prague and Brno	Population coverage: 80% Geosplit: Magyar Telekom (East), Telenor (West), exemption Budapest
5.	Market impact	Started: from 2011 (3G rural), from 2014 extend for 2G and 4G also 3 MNO market, HHI is: 3447 Parties: T-Mobile (No.1 player) and O2/CETIN (No.2 player)	Started: from 2014 (4G 800MHz), 2016-2019 temporary for 3G (900MHz) rural 3 MNO market, HHI is: 3517 Parties: Magyar Telekom (No.1 player) and Telenor (No.2 player)
6.	Operational model	contractual (reciprocal)	contractual (4G reciprocal; temporary 3G one-way sharing)
7.	Duration	from 2011 and 2014, end N/A transfer price: not disclosed but, offered commitment in 2021 contains cost-based offer also	from 2014, end 2029 (expires the 800MHz license) (temporary only 3 years till 2019) transfer price: no public information disclosed
8.	Driver	commercial driven	commercial driven

Source: Author's own summary

Author's assessment

Based literature review on regulatory framework approaches and recommendations, it can be expected that regulators (especially competition) would not give an acceptance for these NSAs.

Regulatory concerns might be the active sharing (both cases), even the spectrum sharing in HU, large proportion of population covered, high density urban areas covered except 1 or 2 biggest cities), on a three-player market and the market leaders join the forces.

Regulators might consider in the Czech NSA case, that spectrum is not shared, 2 largest cities are excluded, contractual (reciprocal) operating model used, and HHI is not deviates significantly from other three-player markets. In the HU NSA case the consideration might cover that spectrum sharing allowing higher network quality (bandwidth, capacity, speed), 800 MHz in rural, coverage type spectrum, only one layer, the involved 800 MHz is out of seven spectrum layers from 700MHz to 3600MHz, the participants took place unilaterally into spectrum auctions, 4G served in all bigger cities by other capacity spectrum layers also (1800, 2600 MHz), HHI is not deviates significantly from other three-player markets, the operating model is contractual (reciprocal), and one of the participants slipped back to 3rd position into the market. Related urban areas it should be highlighted one more that in spite of 800 MHz shared also in high density urban areas with exemption of Budapest, the 4G LTE service provided by not only 800 MHz coverage (deep indoor) layer, but also 1800 and/or 2600 MHz capacity layers, which are not shared, thus from capacity perspective there is differentiation in RAN segment also.

Regulatory assessment

Czech market

In 2015 Czech Telecommunication Office (CTU, the Czech NRA) assessed ex-post the NSA and published an informal opinion. CTU stated that has no competence to enforce competition law, however according to CTU no negative impact expected on the retail level of competition, but long term effects on innovation and deployment of new technologies need to be monitored. CTU acknowledged that infrastructure costs are only a minor component of total costs of operators, CTU did not see a risk that cost communalities restrict retail competition. Furthermore, CTU did not see a risk that the remaining competitors were pushed out of the market due to significant cost disadvantage. Based on the information CTU received, CTU did not see a risk of tacit collusion. CTU also did not see a risk on the wholesale market and the related investment in coverage. (BEREC [2018])

Czech Antitrust Office (the Czech NCA) already launched a preliminary investigation in 2015.

In 2016 European Commission formally opened an inquiry and Directorate-General for Competition (DG competition) started data collection. EC's preliminary competition concern as that "... network sharing agreement restricts competition ... in the more densely populated areas of the country". The Commission's press release said that, given the high market concentration, the NSA between the two main mobile operators in Czechia restricts competition

and thereby harms innovation in breach of EU antitrust rules. The NSA risks slowing down quality improvements in existing infrastructure, and delaying or hindering the deployment of new technologies, such as 4G/LTE and future technologies, and new services, in particular in densely populated areas. EC added, if this were the case, the NSA would be contrary to Article 101 TFEU rules that prohibit anticompetitive business practices. (European Commission [2016])

In 2019 EC has issued a Statement of Objections and according to the preliminary view NSA restricts competition in breach of EU antitrust rules. EC confirmed it's concern on that the network sharing agreement between the two major operators in Czechia reduces competition in the more densely populated areas of the country. It is assumed that the NSA is likely to remove the incentives for the two mobile operators to improve their networks and services to the benefit of users. EC however stated, that the assessment concerns current and legacy technologies (2G/3G/4G), without any consequences to any future potential NSA or technology (e.g., 5G). (European Commission [2019])

In 2021 PPF Group (O2/Cetin) and Telekom Group (T-Mobile CZ) offered a commitment to EC to reach an end of the antitrust investigation. The proposed commitments contained the following aspects: deploy multi standard RAN equipment in certain layers, apply cost-based pricing of unilateral network deployments or services on behalf of the other operator, limit information exchange between parties sharing the network: CETIN to prevent information spill over between O2 and T-Mobile, new arrangement to remain in force until 2033 and EC can appoint a trustee to monitor the parties' compliance. (European Commission [2021])

Hungarian market

In 2015 NMHH, the Hungarian NRA was notified by Magyar Telekom and Telenor Hungary about the NSA to mutually and partially share the spectrum with each other in the 4G LTE 800 MHz band nationwide with exception of the capital Budapest. NMHH approved the lease, as a secondary trading. NMHH declared, the agreement enabled both operators to offer a larger capacity and better technology characteristics. NMHH examined that the individual obligations linked to the individual licenses are fulfilled. As NMHH had no competence to examine the competition law aspects of the lease agreement, NMHH sent its decision to the NCA for information. (BEREC [2018])

In 2015 GVH, the Hungarian NCA launched the investigation process with respect to the NSA.

In 2018 GVH held unannounced inspections at both parties of the cooperation in order to examine whether there was collusion during the spectrum tender in 2014. So the NSA related investigation was extended for last spectrum tender, contained 800 MHz. The aim of the investigation was to assess whether the agreement may have been aimed at sharing the relevant market in advance and at coordinating the bids of the undertakings with the purpose of fulfilling the tender's conditions. These practices may have violated provisions of the Hungarian Competition Act and TFEU, which prohibit agreements restricting competition. (GVH [2018])

In 2019 GVH communicated that investigation still ongoing. Probably the Hungarian NRA also wait for the EC final decision related the Czech NSA case.

Based on the Hungarian regulatory concerns related to the NSA, the approval process is dominated by spectrum aspects due to MOCN type of agreement and there were less detailed comments on the principle of an active-passive network sharing.

5. Empirical assessment of competitive effects of Czech and Hungarian NSAs

The purpose of this section to provide an empirical analysis of the measures listed in section 3. on Methodology (Table 6.), following the OECD [2014] and BEREC Common Position [2019] structures on potential procompetitive and anticompetitive effects. The aim is to validate in the Czech and Hungarian NSA cases, whether network sharing's net impact is positive, when benefits outweigh potential harms in line with TFEU Article 101(3) and therefore contribute to social welfare. This section is divided into 6 subchapters to assess network quality, cost reduction and efficiency gain fair sharing, transfer price impacts, market context (concentration, market share), incentive for competition (differentiation) and incentive for investments.

5.1. Network efficiency improvement

The main expected benefit of mobile network sharing is the improved Network quality that means faster and wider rollout of high-speed networks coverage (in particular in low density, rural areas) and higher quality (for more parallel users and/or higher download/upload speed). Both the CZ and HU cases refers to 4G LTE network rollout, so coverage, capacity, speed as well as the actual usage trends (mobile data traffic in GB) are the relevant measures to assess the improvement.

Coverage

The cost driver of telecommunication investments moved from voice to data traffic in the last decade. Newer generations of technologies are introduced to increase technology and cost efficiency of data transmission. Therefore the expected NSA benefit for more and faster rollout can be measured related to 4G LTE mobile broadband internet from coverage, capacity, speed and usage aspects. The time horizon for research is the 4G LTE matured period, before 5G started to evolve.

4G related NSAs started in 2014 in CZ and HU and Table 9. shows the coverage status at the matured period.

Table 9. Overview on CZ and HU 4G coverage surplus

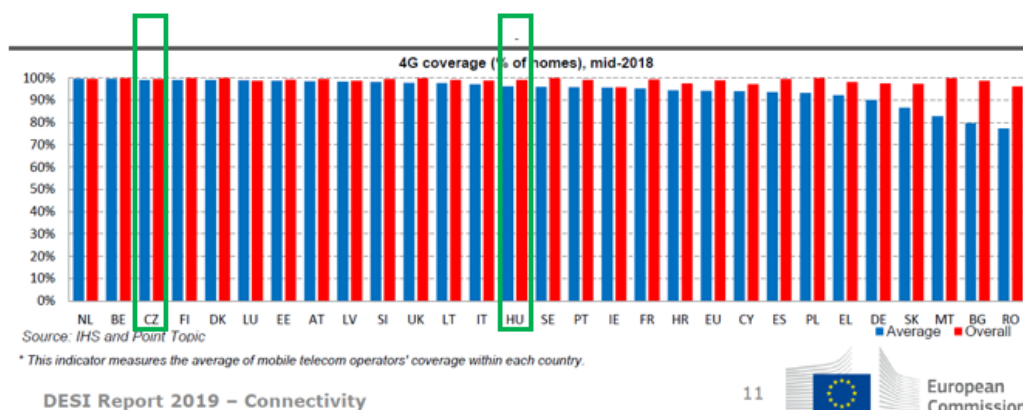
4G coverage (% of households [average of operators])	2018	2019
EU	94%	96%
Czech Republic	99%	100%
Hungary	96%	97%

Source: Author's summary based on DESI [2019] and DESI [2020]

Table 9. displays that both CZ and HU had higher coverage in the early matured period of 4G, compared to EU average. It means that the 4G rollout was more and faster, including earlier and with higher rate covered rural areas, than in other EU countries. The Network sharing cost efficiency and appropriate timing definitely contributed for these results. The timing was essential in case of Hungary, as the sharing started just after the rural and deep-indoor relevant 800 MHz spectrum tender closed, so the whole 4G LTE 800 MHz network planning could be carried out under the geosplit sharing concept to realize the highest cost savings. It was the driver of same amount investment led to higher coverage in the certain time period.

Based on DESI [2019] report, Figure 5. presents the country split of 4G coverage in the EU in 2018. CZ had a 3. position at high-end and HU was also in the mid-high segment.

Figure 5. Overview on 4G coverage in the EU, 2018

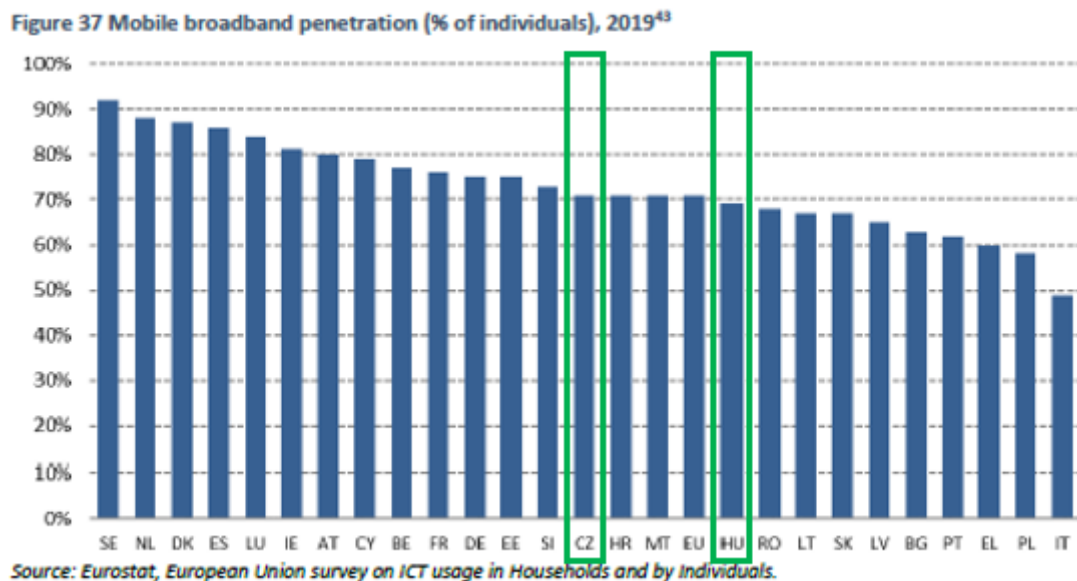


Source: DESI [2019]

Penetration

4G Coverage is the enabler to access mobile broadband data, and Penetration shows the realized take-up of the service. Penetration ratio is driven not only by 4G coverage (the service availability), but also service price (affordability), among other factors, like customer demand for mobile broadband internet. Figure 6. provides an overview on penetration EU-wide.

Figure 6. Overview on 4G penetration in 2019



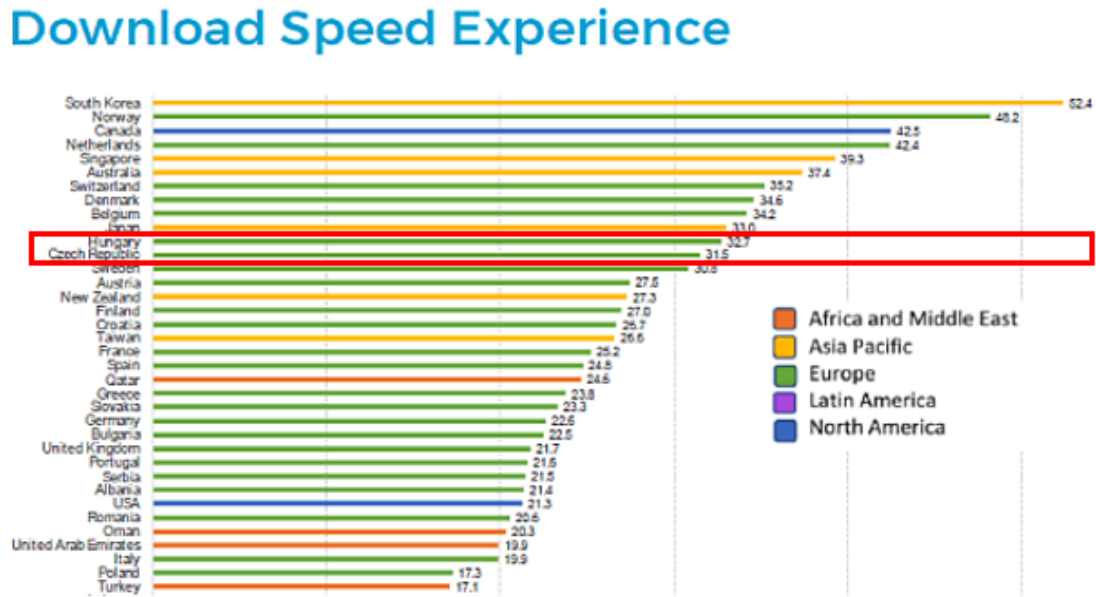
Source: DESI [2021]

The latest DESI [2021] report shows, that CZ in the mid, HU in the mid-low segment. In case of Hungary this position is already a remarkable progress, as earlier HU was on the low-end segment reported in previous years DESI reports. The NSA ensured coverage and price reduction may have contributed to improving penetration data.

Capacity (Speed and Quality)

Besides coverage, the capacity is the other decisive characteristic of the network. Capacity drives the download and upload speeds of the network that may vary in line with competing users in the cell or distance to the base station. Figure 7. shows the download speeds in a worldwide comparison from OpenSignal in early 2019.

Figure 7. Overview on 4G download speed experience in Q1 2019



Source: Opensignal [2019]

The download speeds are in the high segment for both Czech Republic and Hungary. 4G NSAs may contributed for this overall result, providing a good quality at rural country sides also.

Table 10. displays further network quality characteristics and the ranking of CZ and HU.

**Table 10. Overview on HU and CZ ranking in Opensignal key-metrics
(ranking in each metric out of 87 countries from the world)**

Countries	4G availability	Video experience	Download speed experience	Upload speed experience	Latency experience
Czech Republic	11.	3.	12.	5.	3.
Hungary	8.	2.	11.	8.	2.

Source: Opensignal [2019]

Based on Opensignal report, out of 87 countries worldwide the ranking of CZ and HU in each network quality characteristics were in the 2nd – 12th range, that refers quite good network quality. The NSAs also contributed to consumer perceive high quality level at mobile networks.

In case of Hungary the MOCN NSA (network sharing includes spectrum sharing) also contributed for the good results. NSA participant Magyar Telekom and Telenor in the 800 MHz spectrum tender in 2014 successfully acquired 10-10 MHz blocks unilaterally, while the outlayer Vodafone also yield 10 MHz. Due to spectrum sharing the subscribers of Magyar Telekom and Telenor could benefit from double (20 MHz) bandwidth if other network circumstances enable it.

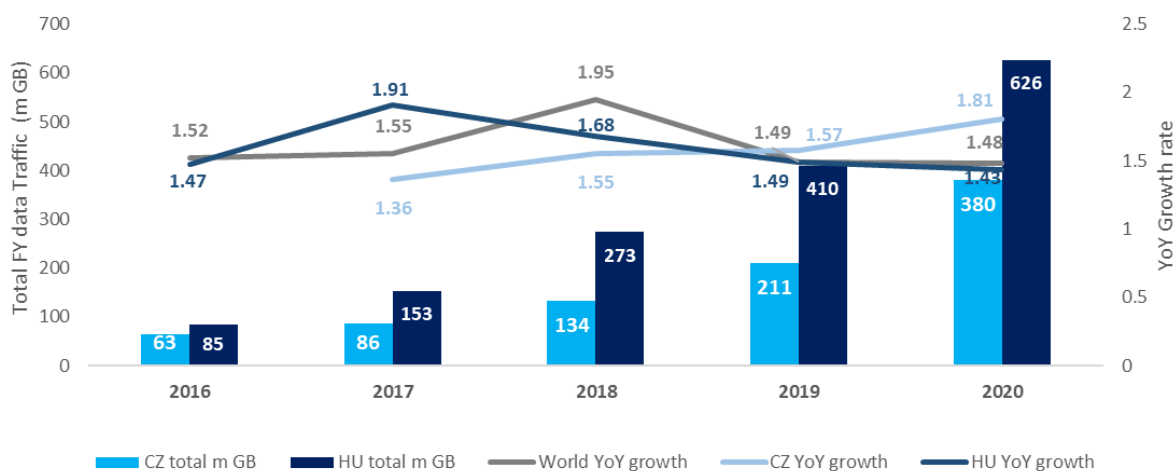
Maier-Rigaud et al. [2020] also provided an empirical based analysis on the CZ market through a structural model of competition (supply and demand side) that the NSA contributed to the network quality increase also. (details introduced in 5.2 section)

Mobile Data usage (GB traffic)

The availability of high level coverage and capacity, as enabler plays a key role in encouraging customers to use the network. Real mobile data usage influenced by several factors, like fixed broadband internet and TV service availability, and relative price to it, but also take-up of content, provided by Hyperscalers, like Netflix or YouTube video. Related to data usage from Network management perspective the 2 key drivers are the total data traffic (and its year-over-year increase) and the monthly unit level data usage (per subscriber). Ericsson Mobility report as an industry benchmark provides good comparison baseline at world, EU and CEE level for these drivers, based on that the progress of data increase can be assessed.

Figure 8. presents the total data traffic growth as well as the yearly growth rate of the traffic.

Figure 8. Overview on Total Data traffic growth in CZ and HU

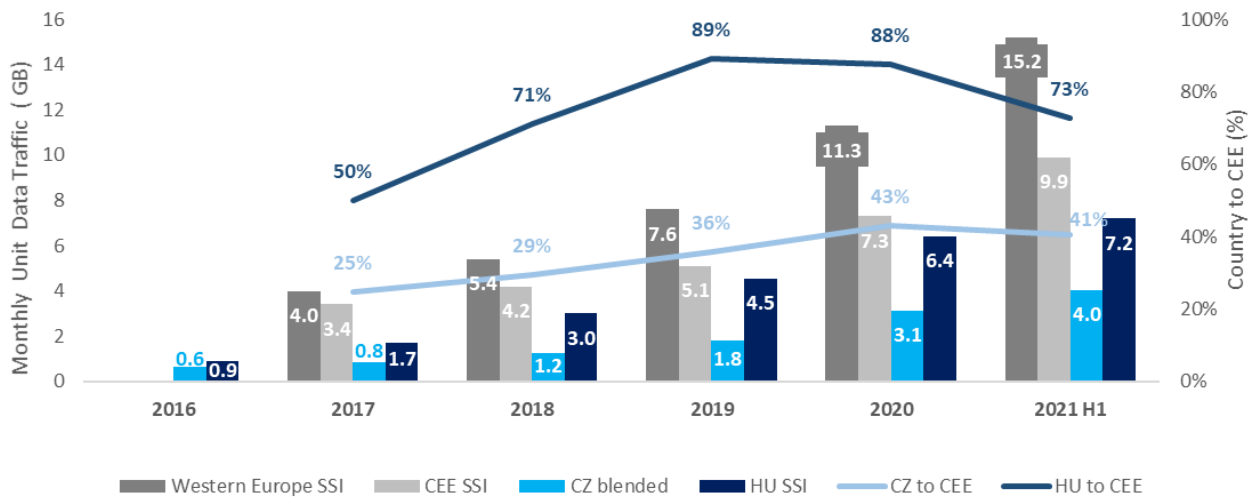


Source: Author's summary based on NMHH [2022], CTU [2021] and Ericsson [2021]

The CZ data is without Fixed Wireless Access (FWA) traffic (used for fixed broadband Internet substitution), but in the HU and Ericsson data it is not set aside, however before 2020 it was not a substantial part of the traffic, so may not cause a substantial distortion. The figures show that in Hungary the data consumption is higher and yearly dynamic also deviates. In HU after the NSA related 4G LTE 800 MHz network major part rolled out (2016-2017) there was a tremendous traffic increase (almost double the traffic), which was 1 year ahead of data blowup at worldwide. In case of HU, the NSA led faster rollout was the definite driver of data growth and that enabled one of the NSA participants (Telenor Hungary) to launch an out of box marketing strategy for data packages, that blowout total country traffic (detailed description will be provided in 5.5 differentiation section). In CZ there was an almost fully linear increase, after a slower take up, at the end of the period, the growth exceeded world average. Here the NSA impact came in the mid-run.

Figure 9. shows the unit level data traffic compared to Ericsson Mobility report CEE and Western European data.

Figure 9. Overview on Monthly Unit Data traffic in CZ and HU



Source: Author's summary based on NMHH [2022], CTU [2021] and Ericsson [2021]

The HU unit data traffic growth was also higher, than the CZ, however lag behind to the CEE or even Western Europe average data. In Hungary the NSA enabled total traffic growth contributed to the catch-up and reaching 89% of the CEE average in 2018 due to the mentioned Telenor offer, but later the growth slowdown, when reaching 5G area. The CZ data shows a linear approach to the CEE data, but not yet reached the 50% of it.

The finding of this section clearly indicates, that mobile network sharing agreements made a real contribution to the network efficiency improvement via more and faster 4G rollout, therefore increased social welfare in CZ and HU. From 2016 the EC's assumption on slowing down and delaying infrastructure improvement related to CZ NSA not stands.

5.2. Cost reduction and efficiency gain fair sharing

Cost reduction

The main incentive for telco operator to meet customers increasing data demand on a Total Cost of Ownership (TCO) controlled way in terms of both OPEX and CAPEX. From Operator side, the Network related OPEX (site rental, energy cost, operational & maintenance cost, personnel cost, transmission cost, spectrum yearly fees) were responsible for 48% of telco Total OPEX in 2021 based on Analysys Mason [2021]. Allocating the cost to RAN-Transmission-Core Network domain split, the RAN part is most dominant.

The Mobile network Sharing related cost savings may reach 30-40% of RAN CAPEX-OPEX in a passive + active MORAN sharing, based on summarized consultancy findings in Table 2. The total company level impact may reach or even exceed 10% of OPEX. CAPEX level savings come through via lower depreciation and cost of capital costs that operators' pricing have to take into consideration at long run also to ensure return on assets and fund the upcoming lifecycle change investments (RAN lifetime may reach 10 years).

Concluding, a 30-40% NSA related efficiency gain results some 10% cost savings room at company level, compared to without sharing agreement case, presented in Table 11.

Table 11. Overview on telco operator cost structure and NSA savings impact

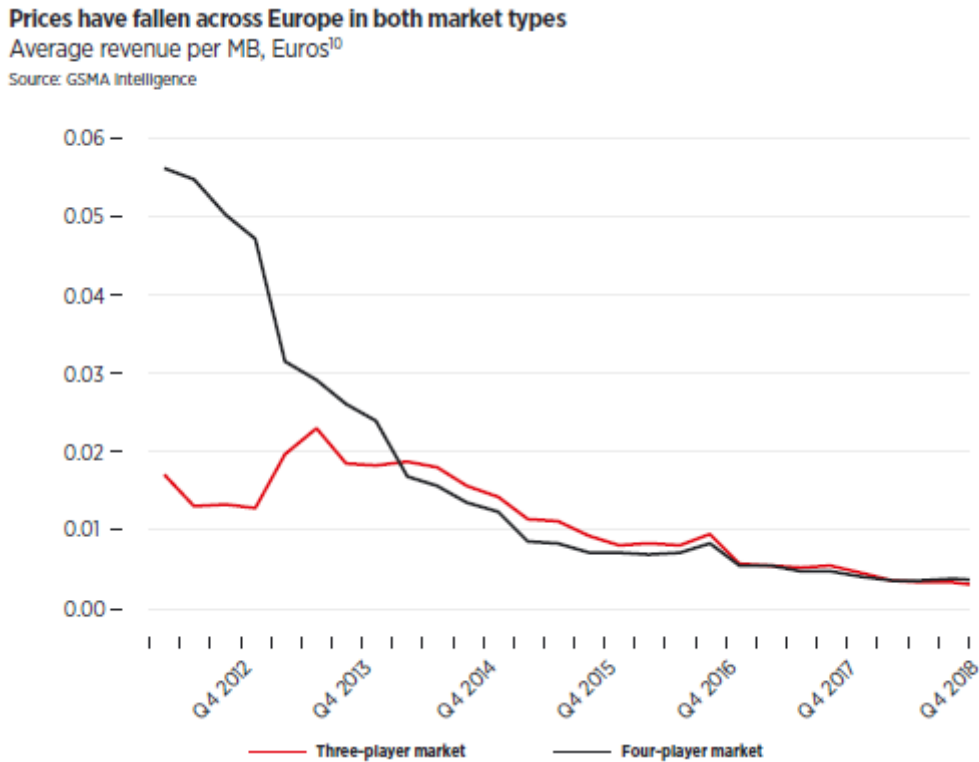
MNO OPEX	Cost ratio	NSA cost reduction (MORAN)
TOTAL OPEX	100%	10-15%
<i>Thereof Network OPEX</i>	48%	25-35%
<i>Thereof RAN OPEX</i>	85%	30-40%

Source: Author's summary based on Analysys Mason [2021] and Telefonica [2019]

GB unit revenues

GB costs, therefore the GB prices also decreasing without Network sharing, as data traffic growth exceed the cost increase, that should be kept under tight control. Very often levers of price decrease, coming from the new technology generation and additional cost efficiency actions, like network sharing are difficult to be set aside at actual data level. Figure 10. displays the average revenue per MB reduction over the research period, when most NSA's came into force in Europe, but also 4G related technology efficiency enabled the price decrease in the competing markets.

Figure 10. Overview on Revenue/MB fall



Source: GSMA [2020]

CZ empirical model on active NSA benefits

In the topic of efficiency gain pass through to customers, Maier-Rigaud et al. [2020] provided an empirical based deep research related to the Czech market. The model contained 2 parts: (1) based on difference-in-differences (DID) approach it was found that active NSA led to a significant reduction of prices of baskets of mobile services compared to a control group of other European countries; (2): a structural model of demand and supply for mobile services that was used to further decompose the effects and according to the findings, active NSA led to both lower costs and increased network quality.

The DID model based on Teligen/ StrategyAnalytics/ OECD data on all mobile tariffs from the top two MNOs in each quarter for European countries. Tariffs were grouped into four different usage baskets that vary by the number of minutes and text messages as well as the volume of data usage. Control groups were defined, the first control group used for the mainline results, countries without active NSA, that contained Belgium, Estonia, Germany, Italy, Latvia, Luxemburg, the Netherlands, Norway, Portugal, Slovakia, Slovenia and Switzerland. For the second control group in the robustness analysis, countries with MNO entry, exit or a merger

were excluded, so it contained Denmark, Finland, Greece, Hungary, Iceland, Latvia, Luxembourg, Poland, Slovakia and Switzerland.

Findings are summarized in Table 12. from Maier-Rigaud *et al.*

Table 12. Overview on Difference-in-Difference model finding for CZ NSA

NSA effect	Usage basket			
	S	M	L	XL
Overall	-0.1 %	-10.8 %	-15.0 %	-32.9 %
By year				
2014	-0.5 %	-10.8 %	-15.0 %	-32.9 %
2015	1.7 %	-7.0 %	-13.8 %	-30.0 %
2016	-8.2 %	-12.8 %	-17.1 %	-35.9 %

Source: Authors' calculations based on data from Teligen, BEREC and Thompson Reuters.

Source: Maier-Rigaud *et al.* [2020]

Maier-Rigaud *et al.* found for the non-small usage baskets a consistent negative and economically meaningful, significant effect of the NSA on prices, that vary from -10.8 % to -32.9 %. Their finding was that the NSA had a beneficial effect on consumers, at least in terms of price, while the quality of the mobile services measured by the second model.

The objective of structural, supply and demand model was to distinguish between the cost-reducing and quality-enhancing effects of the NSA. Analysys Mason data were used on prices, and own-price elasticities for each operator. Findings are summarized in Table 13. from Maier-Rigaud *et al.*

Table 13. Overview on structural model finding for CZ NSA

Year	T-Mobile	O2	Vodafone	Δ Consumer surplus	
	------(Percent)-----			-----(€/consumer)----	------(Percent)-----
2015	-10,11	-9,21	-1,78	58,5	9,8
2016	-10,05	-9,09	-1,86	68,8	10,8
2017	-9,84	-8,88	-1,86	81,2	11,6

Source: Maier-Rigaud *et al.* [2020]

According to Maier-Rigaud *et al.* the results show that the NSA both increased quality and reduced cost, so that the cost reduction did not adversely affect network quality, so active RAN sharing had sizeable beneficial effects for consumers.

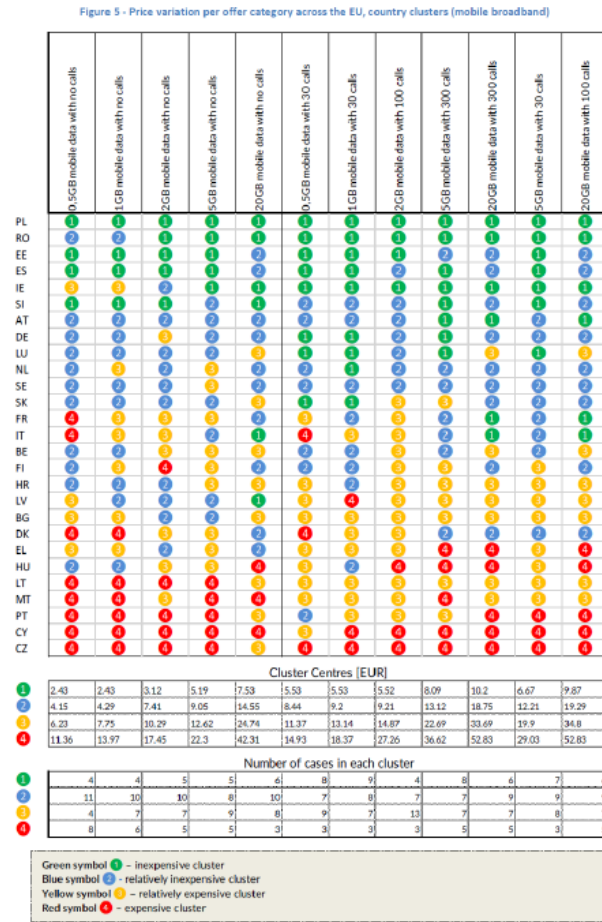
Summing up the study of Maier-Rigaud *et al.*, it shows that the prices of NSA participants decreased at nominal level (outlayer Vodafone also followed with a lower ratio as an “umbrella effect”), active RAN sharing had an additional savings compared to passive only savings and the total consumer surplus estimation (10-12% above) is by and large in line with the 10% OPEX savings room estimated in Table 11.

CTU findings on mobile prices

The Czech NRA, CTU in its market analysis argues that retail prices of mobile services, especially data, are significantly higher in the Czech Republic compared to the European average, therefore CTU would like regulate the wholesale mobile access market by setting maximum prices. It is said that the current wholesale prices higher than retail, that makes it impossible for MVNOs to offer competitive tariffs. This was CTU’s third attempt to regulate the mobile market, as first proposal was rejected by the EC, arguing that the CTU did not sufficiently prove the joint dominance of the three network operators. (CTU [2022])

Regarding mobile prices CTU refers for the yearly Empirica [2021] report on telecommunication prices made for the EC, in which CZ prices are among the most expensive according to the applied methodology. CTU applied Empirica summary table shown in Table 14.

Table 14. Overview on mobile prices in bucket view for EU in 2020



Source: CTU [2022], Empirica [2021]

Based on Empirica report CZ prices are in the most expensive cluster (one exemption out of twelve baskets) independently form the incorporated amount of voice and data usage in each buckets.

It is doubtless that mobile GB unit prices are in majority falling, as operators apply the principle, that ask for a little more (money) to provide much more service (e.g., data) when they force upgrade migration or sometimes just double the data usage limit without a price change. However prices decreasing in all peer markets in the benchmark, therefore the relative position might be unchanged, or even worsen, despite the decreasing nominal prices.

Retail price benchmarking

In the EU one of the most accepted telco price benchmarks is the **Empirica report**. The methodology of the report built on data gathering on public offers from operators (website), that validated by the NRAs, then matched to usage buckets of voice and data.

Only the two or three largest MNOs in a country included, that has combined market share of at least 70%, but it remains possible that a smaller MNO or Mobile Virtual Network Operator (MVNO) has a less expensive offer that not included into the benchmark. Prices are exchanged to EUR and harmonized by Purchasing Power Parities (PPP), that may result a slight increase in pricing, so may worsen relative position of developing countries from CEE.

The buckets are harmonized with OECD Teligen buckets and show relative stability for several years. The applied usage patterns are closer to developed countries' usage profile with high level voice calls, however not follows that the data traffic yoy increases by 50%, so customers quickly reach the highest data usage packet, while the voice usage never will reach the category limit. There are mobile voice and data (bundled) baskets, which represents the normal smartphone usage (called Small Screen Internet - SSI) and mobile data only baskets, which are the data only SIMs for e.g. laptops (called Large Screen Internet - LSI).

Table 15. contains the most relevant baskets for CZ and HU usage profile, that is worth to being scrutinized.

Table 15. Overview on CZ and HU usage patterns and Empirica baskets

Countries / Baskets Data in 2020	Voice (call unit)	Voice (minutes)	Data (GB)
CZ (blended SSI and LSI) w/o FWA	50	138	3,1
HU SSI	70	243,9	6,4
HU LSI (w FWA)	0	0	28,3
Empirica I6 basket (voice and data - SSI)	30	80	5

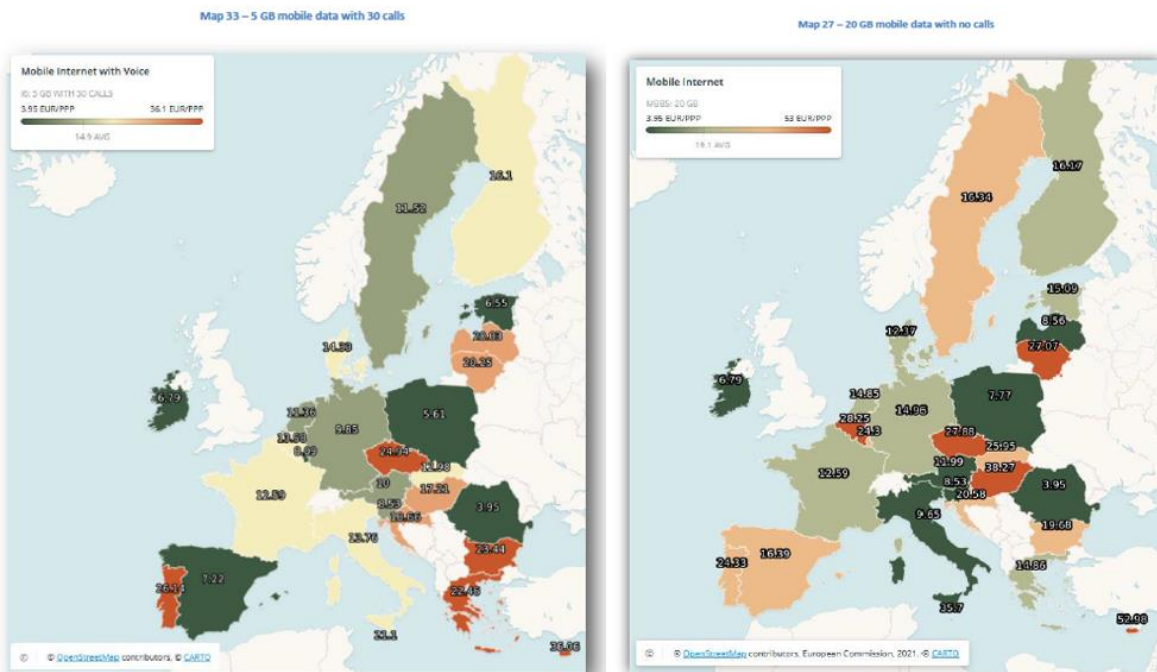
Countries / Baskets Data in 2020	Voice (call unit)	Voice (minutes)	Data (GB)
Empirica I4 basket (voice and data - SSI)	300	150	5
Empirica MBB5 basket (data only - LSI)	0	0	20

Source: Author's summary based on Empirica [2021], NMHH [2022] and CTU [2021]

Out of 7 mobile voice and data bundled and 5 mobile only buckets (see in Table 14. in the columns) the I4 and I6 bundle and MBB5 mobile only data baskets are the most relevant for the CZ and HU average usage habits (see in Table 15.) In the followings the I6 and MBB5 baskets analyzed and the relative position of CZ and HU assessed in them.

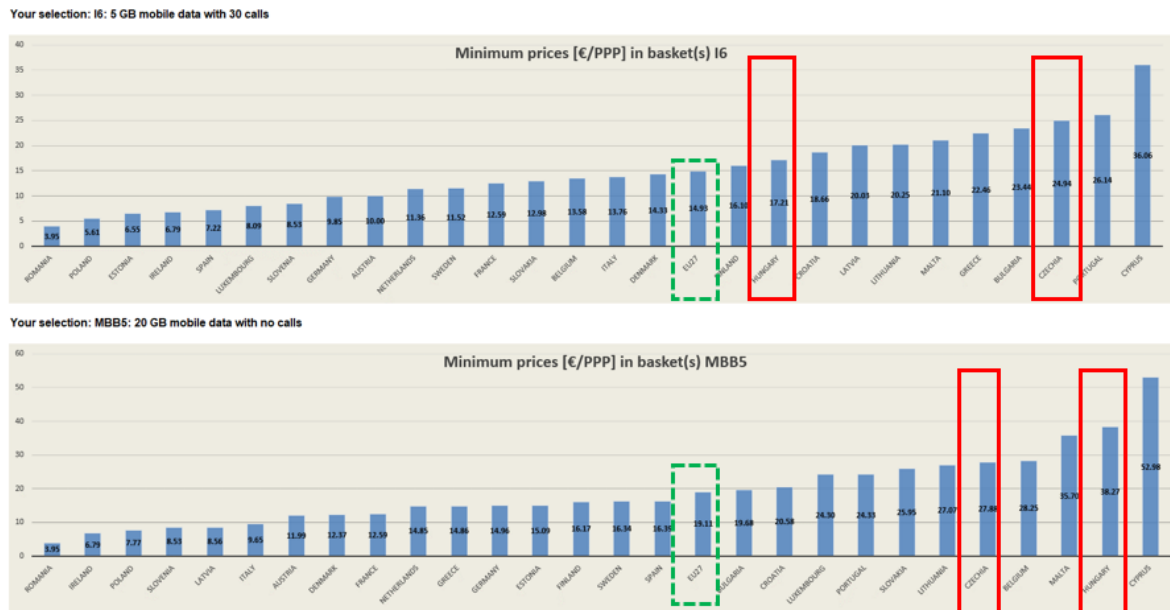
Figure 11. shows the I6 and MBB5 basket relevant overall findings and the Figure 12. displays the detailed ranking.

Figure 11. Overview on country prices in I6 and MBB5 baskets



Source: Empirica [2021]

Figure 12. Detailed country price ranking in I6 and MBB5 baskets



Source: Empirica [2021]

Based Figure 11. and Figure 12. both CZ and HU markets belongs to the (most) expensive markets in voice and data bundle and data only most relevant baskets, covering average usage habits. HU position is better in bundled I6 package, but almost at the high-end in data only segment. Having a look to Table 14., it can be seen for HU that although many buckets are just “relative expensive” (yellow), mainly those buckets are (most) “expensive”, where the average data usage fits. The CZ offers fell into the (most) “expensive” category in all baskets, except one bucket. If we look previous years Empirica benchmarks, the findings are similar.

Other standard reports show quite similar picture also. The **OECD Mobile voice and Data as well as the Mobile Broadband reports** made by Teligen Strategyanalytics available on subscription. The **Rewheel researcher** consultancy also provides subscription base reports, that’s findings are similar on both CZ and HU belongs to the mid-high price segment in the EU in 2022. (Rewheel [2022])

Standard price benchmark reports show that CZ and HU mobile data prices belonged to mid-high and high segments of the EU still in 2020-2022. Although there are several potential distortion factors (TOP 2 MNOs involved, PPP used, exchange rate impact, internet VAT allowance handling, not appropriate fitting of baskets to average usage habits) the messages are unified: in EU comparison the prices are relatively high in the analyzed CZ and HU markets. It

might refer for less efficiency gains of NSAs shared in comparison to other markets. In the majority of EU countries some kind of Network sharing takes place (at least passive), that may have different efficiency gains, that's different share passed thorough to the customers. Probably in those countries that ranked into more expensive categories in price benchmarking, smaller part of the NSA's efficiency gains passed through to customers.

There is a difficulty in reaching a final conclusion on whether fair share from NSA related efficiency gains passed through to customers, therefore to what extant contributes to overweight potential anticompetitive effects and promote social welfare. Standard price benchmark reports indicate that although GB unit prices are falling, the relative position of CZ and HU markets did not move from mid-high expensive segment compared to EU 27 countries. It definitely means that there is no over improvement from CZ and HU NSA efficiency gains sharing, as other European countries also managed to decrease prices (at least unit level) with the same pace. This fact is even though CZ and HU apply the active NSA, that may have higher efficiency gains, compared to EU countries, where MOCN NSAs are very rarely accepted and MORAN sharing also less common. The Czech NRA, CTU also use these benchmarks as a reference for planned actions related to the mobile wholesale access prices.

This indication stands in contrast to the model of Maier-Rigaud et al., that argued for extra efficiency gain and price decrease realized in 2015-2017 time period compared to non-active sharing countries, however window of analysis deviates from currently used 2020-22.

Final conclusion is that, it is not clear, whether fair share of efficiency gains passed through customers, despite realized cost reduction.

5.3. Excessive access or transfer pricing

The aim of this section to assess information on potential **excessive access or transfer pricing** that may drive retail price increase and shorten competition and worsen social welfare. Thus, access or transfer price is an indicator of potential anticompetitive effects of NSA.

Very limited public information available on charging mechanism between NSA parties. It is known that neither of the CZ and HU NSA built on cooperative agreements (special joint venture), but on contractual agreement (reciprocal access sharing). There are no public and transparent list prices or any condition list published, therefore the pricing principles and whether excessive price used are unclear.

The only available public information is that, in CZ O2/Cetin and T-Mobile CZ in 2021 offered a commitment how to modify the agreement in order to close the EC DG competition investigation. It contained a commitment of “deploy multi standard RAN equipment in certain layers, apply cost based pricing of unilateral network deployments or services on behalf of the other operator”. The cost-based approach appeared here.

On the CZ market based on CTU market review process it was identified, that the wholesale mobile access prices to data were higher, than the retail market. It is unknown whether this is sign of excessive transfer pricing among NSA participants or other pricing factors influence wholesale prices.

In HU there are no explicit or implicit information on potential excessive transfer pricing related to NSA.

Excessive access prices may **incentivize foreclosure of other MNOs or MVNOs**. Vodafone was the biggest outlayer telco both in CZ and HU. The most probable reason why Vodafone remained alone in a 3-MNO market may root in corporate strategy. During NSA times Vodafone hold 3rd position in both markets and volume and revenue growth based strategy was in focus, rather than profitability increase by cost efficiency actions. When Vodafone realized financial disadvantages of outlayer position, it would have been difficult go for nationwide asset company model to serve three MNOs both from corporate and regulation perspective. Later on Vodafone corrected that failure and increased focus on cost efficiency, therefore made a successful passive RAN asset restructure into Vantage TowerCO Europe-wide that was well received at the stock-exchange and was also an optimized answer of regulatory reluctance of supporting active MORAN sharing.

Regarding other players in the CZ market, there is a more intensive MVNO market with higher market share compared to Hungary (see in next, 5.4 section), but according to CTU they are unable to really influence retail market prices. In HU MVNOs continuously loosed ground as second brands were retired (Tesco, Lidl Mobile) or acquired (UPC mobile by Vodafone-Liberty transaction). There is one half MNO, half MVNO player, the ex -subsidiary of Romanian Digi, bought by 4IG in 2021. Digi, being successful on the fixed market with disruptive retail pricing strategy, but managed to get only very limited spectrum at 1800 MHz and 3600 MHz in the mobile segment, therefore it was unable to launch a fully-fledged MNO service. Digi made a lot of local deal for passive sharing even with the NSA parties, however such a big deal, that was disclosed as in Germany between 1&1 and Vantage TowerCO, was not announced, so none of the (asset)companies provide a country-wide infrastructure service for Digi.

Summing up, the NSA participants has not allowed transparency on access or transfer pricing and although there might have been candidate for wider cooperation, a countrywide deal has not been introduced, so essentially the original set-up has not changed. On one hand there are no direct information on excessive pricing, but on the other hand no big market entries has happened based on access to the shared infrastructure, so there is a limitation to judge whether foreclosure may have taken place.

5.4. Market context and cost disadvantages

The purpose of this session to assess market context and its changes as market concentration, market share or cost disadvantage might be the indicator of anticompetitive impacts of NSA. If the market concentration is extraordinary high, or NSA participants market share start to raise and parallel outlayer operators' market share or even the profitability to decline, it may indicate market distortion and shortened competition that harmful for social welfare from competition policy point of view.

At first, market context (market position of the partners) is studied in terms of market concentration and market share. There are more approaches to scrutinize market share trends, as it can built on non-financial, volume-based analysis on the traditional, voice service focusing way (active mobile SIM cards- good representation of subscribers), or can be data focused (data traffic generating mobile SIM cards or even data traffic [GB] based). However, operators rather prefer financial, revenue-based market share calculations, in particular the recurring service &

traffic revenue focused one, where potential one-off impacts (mainly handset related) are filtered out.

NSA may cause cost disadvantage for outlayer players, that might decrease profitability if the operator wants to overweight technology disadvantage, then it may spend more to provide equal network quality service level to customers. However different profitability might originate in market structure (market share), as majority of cost are fixed (e.g. covering the whole country by network, or physical shop sales channels), however the lowest market share means the lowest revenue for the same cost. And there is trade-off between profitability and market share, as continues overspending the market may result higher market share, or even a jump in ranking.

Market concentration

Bourreau *et al.* [2020c] provided a market concentration overview for the European market per country that showed in Table 16. Calculations based on GSMA and company data, applying the cumulative criteria of number of network operators (3 or 4) and the industry concentration (measured by Herfindahl-Hirschman Index).

Although telecommunication markets at Europe level are “hyper fragmented”, the number of MNOs in each national market in major cases are low (3 players) or decreasing trend can be expected (4 player market) as operators look for market consolidation opportunities for efficiency. As a consequence, many European markets are concentrated. Based on Bourreau *et al.*, out of EU 27 markets only 9 markets are 4-player and 18 markets are 3-player. Out of 3 player markets, CZ and HU located in the mid-low segment in HHI ranking, that means there are 13 Member States with a higher industry concentration among 3-MNO market.

Table 16. Overview on market concentration (HHI) per country

3 MNOs	HHI	4 MNOs	HHI
BULGARIA	3370	POLAND	2551
FINLAND	3382	SPAIN	2676
NETHERLANDS	3386	ROMANIA	2811
GERMANY	3442	FRANCE	2831
CZECHIA	3447	DENMARK	2856
AUSTRIA	3494	SWEDEN	2952
HUNGARY	3517	SLOVAKIA	3023
ESTONIA	3565	ITALY	3036
PORTUGAL	3583	SLOVENIA	3167
LITHUANIA	3603		
BELGIUM	3624		
IRELAND	3633		
LATVIA	3683		
CROATIA	3714		
GREECE	3761		
CYPRUS	3963		
LUXEMBOURG	3994		
MALTA	4040		

Source: Bourreau et al [2020c]

In 2019 EC DG competition issued a Statement of Objections related the Czech NSA, it found that the network sharing agreement between the two main mobile operators in the Czech market restricts competition and thereby harms innovation in breach of EU antitrust rules. One of the arguments was, that the Czech mobile communications market is highly concentrated with only three mobile network operators, however based on the market concentration comparison in the EU it is revealed that there is nothing extraordinary about the Czech market. Similar statement can be made for the Hungarian market also.

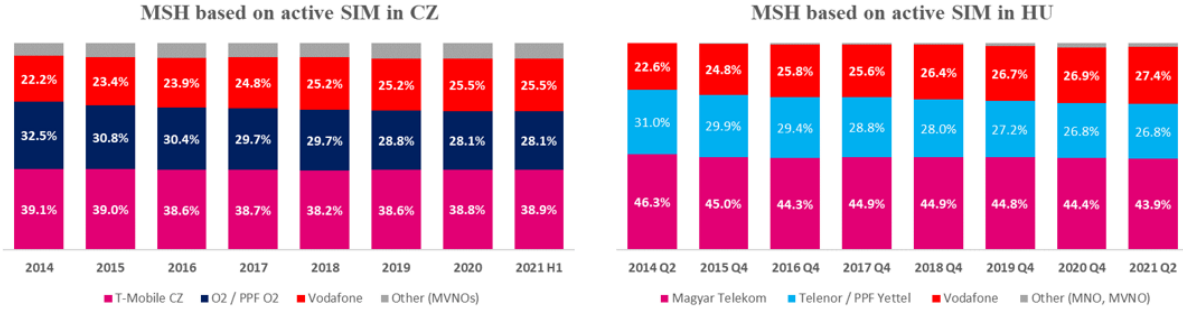
GSMA [2020] conducted that there is relation between HHI and network quality (higher download speeds). The study found that the highest download speeds are available on 3-player market with HHI around 3500, than a 4-player market. This report also says that the operators' capex intensity (CAPEX/Sales %) on country average in a 3 player market is by 2%point higher and reached 16% in 2018, but it acknowledges that on average by 6%point higher EBITDA/Sales profitability ratio realized, exceeding 30% EBITDA margin, compared to 4-player market.

Summing up, regrading market concentration (HHI on a 3-player market) there is no extraordinary market context that would restrict market competition in CZ and HU markets.

Market shares

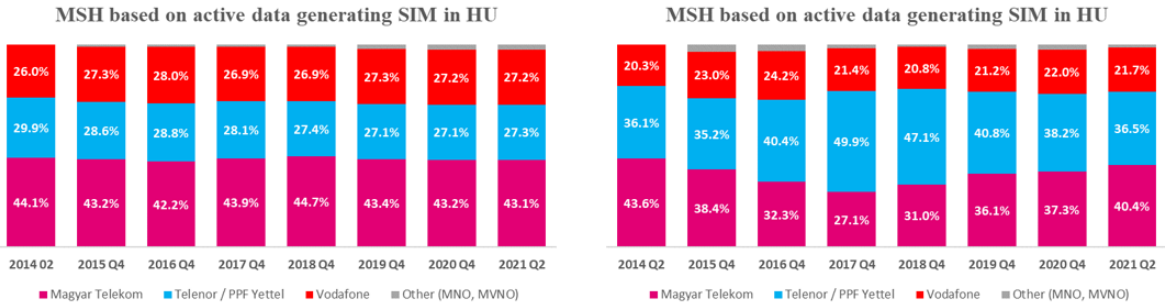
Development of market shares may reveal unfair market behavior and anticompetitive trends, if NSA outlayer companies loosing continuously ground. CZ and HU relevant market share (MSH) trends are displayed on the followings: Figure 13. shows the active (voice) SIM based, Figure 14. the data generating SIM based and data traffic, GB based only for HU and Figure 15. presents the recurring service and traffic revenue based.

Figure 13. Market shares based on active SIM cards in CZ and HU



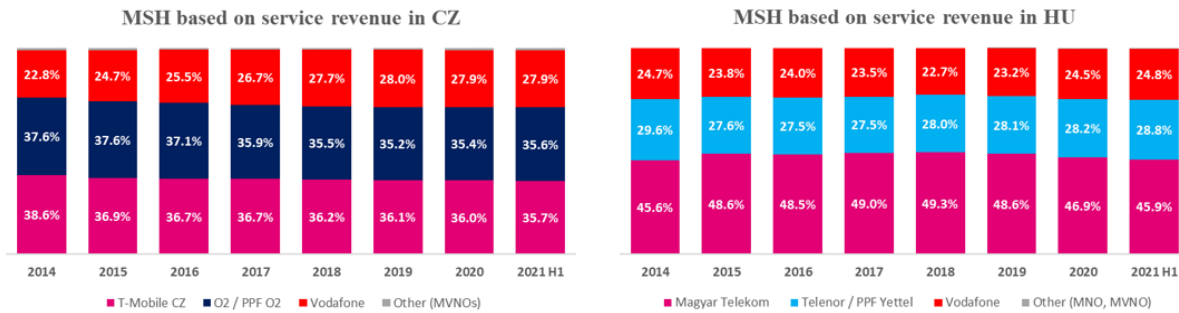
Source: Author’s own summary based on NMHH [2022], CTU [2021]

Figure 14. Market shares based on data generating SIM cards and data traffic in HU



Source: Author’s own summary based on NMHH [2022]

Figure 15. Market shares based on service revenue in CZ and HU



Source: Author's own summary based on PPF [2022]- Analysis Mason data

After a careful scrutiny of all six figures, it is visible, that NSA outlayer Vodafone's MSH in all of the 6 cases has increased both in HU and CZ. The share of other MNVOs, MNOs, also show some slight increase in the majority of the categories. CZ market is less concentrated, than the HU market, where the other category's weight is substantial less.

The highest increase in Vodafone's market share took place in active SIM based comparison in HU, where almost 5% increase was enough to overtake NSA participant Telenor in the ranking and grab the 2nd position (Figure 13.). In CZ Vodafone's revenue market share growth was remarkable, improving by more than 5%, coming from 50%-50% from PPF O2 and T-Mobile (Figure 15.).

In Hungary after NSA came into force and 4G LTE 800 MHz shared NW rollout realized, participants Telekom and Telenor market strategy highly deviated, so incentive for competition and differentiation was not shorten (see more details in next section). On Figure 14 it can be seen that Telenor customers' data traffic share blowup in 2016-2017 to the detriment of NSA partner Telekom. On the other hand, Figure 15. shows that Telekom revenue share increased that refers to a better monetization.

Summing up, the NSAs in CZ and HU not restricted the competition in terms of outlayer operators losing ground, even despite of relative cost disadvantage they managed to improve their market share, that is an indicator of more intensive competition. This trend is an evidence that these unrecommended and opposed NSAs did not restrict the competition and not cause a harm to social welfare.

Cost disadvantages

Based on literature review, cost disadvantage, as an unilateral effect may restrict competition via weakening competitive position of NSA outlayer companies. In practice it means the outlayer company either follows business as usual spending, may result at least temporary quality backlog to NSA competitors, or overspend the unit level spending of NSA participants in order to provide equivalent quality parameters in the new network rollout.

After no market share erosion could be identified for outlayer Vodafone, the profitability have to be analyzed to justify, whether outlayer position has caused remarkable cost disadvantage for Vodafone. The best indicator for operational cost analysis is the assessment of **EBITDA/Sales margin**, that presented in Table 17. for CZ and HU in 2019, after 4G rollout reached matured status.

Table 17. Overview on EBITDA margins in 2019 in CZ and HU

EBITDA /Sales margin (2019FY, After Lease - IFRS16 corrected back)	CZ	HU
Telekom (T-Mobile CZ – pure mobile, Magyar Telekom – converged)	41.2%	29.4%
PPF (O2 - converged w/o CETIN, Telenor HU – pure mobile)	28.1%	36.7%
Vodafone (CZ, HU both pure mobiles)	32.3%	22.3%

Source: Author's summary based on Financial reports for 2019

In CZ although NSA outlayer Vodafone has stable 3rd market position, the EBITDA margin show a healthy picture in the middle of competitor range, so no extraordinary cost disadvantage

can be detected. CTU also noted in 2015 that did not see a risk that the remaining competitor was pushed out of the market due to significant cost disadvantage (BEREC [2018]).

In Hungary the NSA outlayer Vodafone's EBITDA margin lagged behind significantly and stood only at 22.3%. However here the market context and longitudinal data series rather give a proper explanation for low-end value, than cost disadvantage for the HU NSA. Vodafone's market share after more than 15 years entering into the HU market just slightly exceeded 22% on active SIM cards. As mentioned at the beginning of this section on one hand Vodafone's cost structure and amount is similar to competitors, who own 30% or more than 40% of the market revenues, that results a higher profitability. On the other hand the analyzed 2014-2021 period was the time, when Vodafone managed to overtake Telenor and grab 2nd position in the market gradually. Based on Vodafone's strategy the first priority was not the profitability stabilization at a healthy level, but to increase SIM volume and revenue market share, therefore overspent the market, thus EBITDA margin stuck in under 25%. So potential cost disadvantage of outlayer NSA position was just one item, but not the driver of lowest profitability.

The other financial indicator of potential cost disadvantage is **CAPEX intensity (CAPEX/Sales margin)**. Definitely non-NSA participants had to invest more to catch-up in quality with NSA members, however as CAPEX, especially split for Mobile and even to RAN not reported officially, it is impossible to size actual extra investments. However as in Table 2. 30-40% savings expected also for RAN CAPEX that has some 80% proportion from total CAPEX during the 4G investments' peak 2-3 years period, it may have resulted marked extra investment, but not such a tremendous cost disadvantage that could weaken its competitive position, therefore shorten market competition and harming social welfare.

5.5. Decreasing incentive for competition (differentiation)

In the literature review, one of the anticompetitive concerns of NSA refers to decreased incentive for competition. In practically the decreasing differentiation in services of NSA participants are named as potential high-risk restriction for competition, originating for same RAN network, especially in passive + active MORAN sharing.

At theoretical level in section 2.1. Cooperation forms, in Figure 3. NSA milestones and Figure 4. Telco markets it was presented that although passive NSA in coverage and active NSA in capacity may decrease differentiation in RAN segment, for whole Network capability the Core

NW segment is responsible in terms of product and service features. Core segment is unshared and all of the other business (marketing, sales, customer care) and overhead (strategy, communication) functions of the participants are separately managed.

In spite of NSA, preserved differentiation in Network can be demonstrated at the Hungarian market by two case studies.

In 2016, in the 3. year of NSA, when the majority of the 4G LTE 800MHz network was rolled-out, the pure mobile operator Telenor Hungary (still under Norwegian Telenor Group ownership) at the brink of losing 2nd market position in more and more field of competition (e.g., voice, due to unlimited voice perception connected already to Vodafone) launched an out-of-box reverse (data first) offer. It was built on strong Hypernet brand of Mobile broadband internet and the aim was to match the unlimited data perception to Telenor and make a turnaround in its MSH. Telenor Hello Data disruptive marketing campaign communicated the unlimited data offer to which additional voice baskets could be bought (reverse concept to voice packages with supplementary data options) (Telenor [2022]). The enabler was the NSA with more and faster rollout, and as a pure mobile operator wanted to immediately take and advantage of 4G countrywide (both rural and urban) coverage and capacity. As in 5.4. section Figure 14. showed, Telenor's data traffic blowup at that year, as heavy-users and high data users migrated quickly and it took 6 years to the NSA partner Magyar Telekom with substantial higher customer base to get back to original data traffic share, while NSA outlayer Vodafone except of 1-2 years were absolutely stuck in original data share level. It is highly demonstrative example, that NSA participants on the same network how different business strategy can built and how enormous impact can it cause on RAN network usage. The unlimited data based reverse offer was a real differentiator in the market at that time.

The other case related to Magyar Telekom Narrowband IoT (Nb-IoT) offer that was available only NSA geosplit ensured Eastern part of the Hungary on 800MHz except few bigger cities is Western part of the country where in Telenor's 800 MHz geosplit area Telekom provided the Nb-IoT via the 1800 or 2600 MHz for a certain time (Magyar Telekom [2022]). The technology difference might rooted in different RAN and core capabilities of NSA partners, however it not limited Telekom to launch a differentiating service for a niche market, where profitable customer demand was assumed. The linked Nb-IoT map is another demonstrative example for market differentiation between NSA parties.

According to anticompetitive concerns, reduced differentiation might be rooted in **wider information exchange**, that network planning would justify (e.g. retail market strategies) or in **tacit collusion**. Considering differentiation examples above, there are no signs of tacit collusion on the retail market, as NSA participants go with different market strategies on the shared network. However, all current full-fledged MNOs in both CZ and HU markets are highly incentivized to preserve the total market profitability and therefore in competition they do not introduce such disruptive and status quo changing offers that might generate a negative spillover effect for total market profitability.

5.6. Reduced incentive for investment

In line with literature review on potential anticompetitive effects of NSA, there is a special focus on investment incentives besides competition incentives. From a financial point of view, the analysis of CAPEX intensity is a direct assessment of appropriate levels of investments. Indirect evaluation also can be carried out from network performance or retail services points of view.

CAPEX/Sales margin is the industrywide accepted **direct** measure of investments, however as it is a proforma figure and strategically sensitive information, there is a limitation on availability. Based on financial reports Magyar Telekom converged operator has a stable CAPEX/Sales ratio, many cases exceeding 15% without spectrum license acquisition cost and After Lease (IFRS 16 correction back) effect, which is in line with industry investments. PPF Telecom Group, including converged and pure mobile operators as well as asset company, for the CEE region reported an overall CAPEX/Sales margin under 15%, exceeding 12%, as a blended figure of higher converged and lower pure mobile investments. For Vodafone the CEE region reported officially under Other segment, so exact data are limited to local compulsory corporate data or regulatory reporting. Officially published information almost never contains fixed-mobile split or even RAN-CORE-TRM split for the Network investments, so only this overall approach can be used for validation of appropriate investment level.

Regarding **indirect** justification of investments as discussed in previous sections, the network coverage, capacity and quality figures were excellent and in market differentiation also state-of-the-art services were introduced.

Summing up, there is no sign of reduced investments due to NSA. The peak investments period were flatten for participants, but in other periods the normal industry relevant investments took place both in CZ and HU.







6. Conclusion and 5G rollout consequences

The main goal of this study was to assess the Czech and Hungarian mobile network sharing agreements from procompetitive and anticompetitive theoretical aspects and the actual impacts of opposed, unclear, but for 8 years ongoing cooperation for net effect, whether benefits outweighs potential drawbacks.

In order to meet Europe’s digital decade 2030 targets, telecom operators have to invest markedly parallel into fixed fiber and mobile 5G infrastructure, therefore MNOs strive for more cooperation (horizontal agreement) and even consolidation (merger) in the “hyper fragmented” European market to reach better economies of scale, productivity and cost efficiency. Mobile Network sharing, as a horizontal agreement may restrict much less the competition, than a full-scale merger, however both sector and competition regulation has a condition list for approvals.

The more stricter competition policy lays on Article 101(1) TFEU, that prohibits competition distorting or preventing agreements, however Article 101(3) allows an exemption where the restriction is kept to the minimum level and compensated by technical or economic progress, and a fair share of the efficiency gains. The NSA related main procompetitive and anticompetitive effects and findings for CZ and HU are summarized in Table 18.

Table 18. Overview on NSA effects and findings in CZ and HU

#	Benefit/Drawback	Measures	CZ	HU
Procompetitive effects assessment				
1.	Improved Network Efficiency	Coverage, penetration, capacity, speed		
2.	Cost reduction and efficiency gain pass through consumers	Unit cost, retail prices		
Anticompetitive effects assessment				
3.	Excessive access or transfer pricing, incentive for foreclosure	Cost, 3 rd player partnership		

#	Benefit/Drawback	Measures	CZ	HU
4.	Market context and cost disadvantages	Market concentration, market share, EBITDA/Sales		
5.	Decreased incentive for competition (differentiation), incentive for collusion	Different market strategies		
6.	Reduced incentive for investment	CAPEX/Sales		

Source: Author's own summary

Conclusion for 4G

The conclusion of the assessment is that there is no doubt on **network quality** related benefits of NSA and there is no visible investment decrease. The assessment is still positive on **market context** with the only exemption that 1st and 2nd players of the market made the NSA. Market concentration, market share trends do not justify shortening competition and the profitability trends do not display a serious cost disadvantage for outlayer players. There is no absence of **differentiation** in retail perceived strategies (rooted also in RAN segment), so there is no reduced incentives for competition. There is no sign of **tacit collusion**, however there are also no market status quo changing disruptive offers that may jeopardies market profitability. The assessment is unclear related to **efficiency gain pass through customers**, as based on standard benchmarks there is no clear evidence on relative improvement of retail prices compared to other EU countries, however it is doubtless that unit GB prices are falling. There is no transparency on **access or transfer prices** and despite no direct connection can be detected to previous benchmark results, it is an indirect indicator, that the MVNOs has relative low presence and no countrywide access deal has been published with 3rd party cooperation.

The conclusion for net impact is that it seems there is no critical restriction for competition and harm for social welfare, therefore anticompetitive impacts kept at quite low level, that are over weighted by technical and economic progress by efficiency gain partial sharing.

The main finding and the originality of this study, that despite active asset (MORAN) and spectrum (MOCN) sharing NSAs are highly opposed, the benefits outweigh potential drawbacks, the net contribution for social welfare is positive, based on the CZ and HU empirical data analysis.

Definitely there is a room for further lowering anticompetitive impacts and finetuning NSAs in terms of (1) appropriate publicity, reasonable (cost based) and non-discriminatory access terms for certain amount of towers or (2) offer more exemptions in high density areas for not sharing (not only capitals, decrease the inhabitant limits), like in case of INWIT deal in Italy, when TIM and Vodafone made commitments on these, (3) and provide higher share from efficiency gain.

Consequences for 5G

The EC DG competition told in 2019, when issued the statement of objection in the CZ NSA case, that the assessment concerns legacy technologies (2G/3G/4G) and is without any prejudice to any future assessment of network agreements involving emerging technologies such as 5G, which may have very different characteristics. (European Commission [2019])

Despite this clear statement, unfortunately neither in the CZ, nor HU markets have evolved further the NSA, as MNOs might evaluated at high risk to expand the agreement for 5G until existing NSAs are not cleared. This caused two critical problem from cost efficiency point of view: (1) as 4G L800 rural (low density) rollout provided the window of opportunity to launch or extend NSAs and realize the highest savings, the 5G spectrum tendering and 5G rollout was the current window of opportunity to extend NSAs for 5G; (2) while in 2014 the L800 spectrum tender and rollout not related to a full lifecycle (2-3G) network swap as it happened already after 2010, around 2020 MNOs met the need of parallel 5G rollout and 2-3-4G RAN lifecycle swap, that could have enlarged the savings potential for 2-3-4-5G scope in a RAN consolidation. The missed savings opportunity not only a loss for MNOs, but has a cost for society as may slow down data unit price decrease, impacting 5G rollout and penetration development.

GSMA disclosed a study in 2019 on expected 5G cost evolution, that stated the TCO of 5G rollout is higher, than for 4G. Non-standalone (NSA) network costs are less, as utilizing existing 4G network, but allow less new capabilities, while 5G standalone (SA) network costs are more. GSMA said that the 5G baseline cost at TCO level is by 46% higher than the 4G reference cost,

that could be optimized by network sharing and virtualization opportunities to reduce increase to 24% (GSMA [2019]). Analysys Mason had similar findings also (Analysys Mason [2019]). If 5G rollout and 2-3-4G network swap take place parallel, then both the cost baseline and the cost savings can be even higher.

In Hungary the eNET consultancy prepared the National 5G strategy update, in which the bottom-up modeled assumption was, that the operation (OPEX) of 2-3-4-5G network in 2027 could be 1.7 times higher, than the 2-3-4G was in 2019, and the investment (CAPEX) for 2020-27 could be 2.5 times higher, than was in 2013-2019 without virtualization and further network sharing. The assumption for TCO level savings potential was almost 20% with passive sharing and top on came more than 10% additional for active sharing, that was still a conservative approach compared to Table 2. (eNET [2021]).

Conclusion for 5G

There is trade-off between cost efficiency as well as competition and innovation at national regulatory level, that have to be balanced. Based on more consultancy assumptions above, due to lack of expanded NSAs substantial cost savings are missed, therefore cost efficiency was ranked to 2nd position, after competition and innovation. The root-cause is the uncleared competition case by local NCAs and the EC DG competition. **Final conclusion extended for 5G** in CZ and HU is that, on one hand there is a clear missed cost savings opportunity from 5G shared rollout, that may slowdown unit prices decrease and 5G widespread, but on the other hand there is an unclosed evaluation of potential competition restrictions of 4G sharing, that's potential net negative impact based on the findings of this study could not be justified.

Due to data monetization challenges and missing savings incentives from extended NSAs the 5G rollout currently had a slower pace based on DESI report: 5G population coverage was 7% in HU, compared to EU average 14% in 2020 (DESI [2021]). (for CZ 0% was given, that might be lack of information).

Future scope

The evaluation of NSAs' procompetitive and anticompetitive effects in case of EBITDA margin, Market Share and CAPEX margin measures could be analyzed with ANOVA variance

analysis (the relationship between NSA participance and Market share or EBITDA margin or CAPEX margin), as well as correlation analysis between Market share and EBITDA margin. Although cross sectional or longitudinal data analysis planned, due to lack of appropriate amount of reliable data (observation) the SPSS analysis have to be postponed for future analysis.

As EC DG Competition is stated, the evaluation of NSAs may vary on legacy (2-3-4G) or new stack (5G) related. The 5G is not only a newer mobile generation but a technology shift is taking place also with network function **virtualization** (NFV), software defined networks (SDN) that ending up with **open RAN** multivendor concept. At the second part of 5G lifetime the rollout will move **from macro cells to micro cells** in high density urban areas that is also a pioneer case, requiring extra investments and need of cooperation. However NSAs under current regime, especially active sharing, in particularly in the high-density populated urban areas are considered potentially competition restrictive, therefore harmful for social welfare, compared to infrastructure-based competition. The virtualization (NFV, SDN) and open RAN may change the competition landscape in upstream vendor market that may contribute to more differentiation in RAN segment and more intensive competition in downstream market. Therefore **the current competition approach may require a full reassessment related to mobile network sharing in high density 5G macro and micro cell areas** that might be the future scope of next research.

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