Mobile Network Operators' Cost Efficient 5G Deployment with Hyperscalers Co-investment in Public Cloud

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Abstract. The economic recovery from COVID pandemic requires a cost efficient, sustainable and green 5G rollout that should be promoted by harmonization of cost efficiency (corporate finance), competition and innovation (regulatory) aspects.

The aim of this paper to cover technology enabled new cost efficiency scenarios for Mobile Network Operators (MNO) and focus on recently emerged concern of Big Techs (Hyperscalers) co-investment into public cloud in disaggregated, virtualized RAN and Core networks.

The Research Question addressed the question of what is the optimal form to promote Hyperscalers' financial contribution to 5G rollout.

The Hypothesis tested the direct financial contribution as optimal cooperation form, claimed by many operators and politicians for 5G implementations.

The Research Methodology focused on qualitative analysis of incumbent and rival MNOs' financial incentives and competition impact of cooperation, as well as quantitative analysis applied on consultancies forecasted financial data.

The Expected finding emerged from this study is the indirect financial contribution, a co-investment partnership in public cloud might be an optimal role for Hyperscalers. The originality of this paper at academic level to highlight this is a mutual advantageous cooperation in the value-chain both for MNOs and Hyperscalers, despite having its own risk for MNOs by losing network control partially for gaining cost efficiency.

Keywords: Public cloud · Hyperscaler · Co-investment · Mobile network operator · Virtualized ran and core · Cost efficiency · Competition

1 Introduction

The current challenge of the telecom sector is the parallel rollout of capital expenditure intensive Very-High Capacity Networks (VHCN) both in mobile (5G) and fixed (FTTH) for broadband Internet, driven by predicted continuous data increase that in

F. Neri et al. (Eds.): CCCE 2022, CCIS 1630, pp. 47–61, 2022.
https://doi.org/10.1007/978-3-031-17422-3_5

case of mobile reaches CAGR 24% growth till 2027 according to latest Ericsson Mobility Report (Ericsson Mobility Report 2021). 5G small cell density and the requirement of ultra-reliability low-latency communication capabilities even further increase Total Cost of Ownership (TCO), that long-term questions the financial viability of infrastructure competition (parallel 5G networks) in all network layers. In addition, as Mobile network generations' lifecycle is becoming shorter and more overlapping eachother, the Return on Capital Employed (RoCE) figures are also worsening, many cases not reaching Weighted Average Cost of Capital (WACC), driving one of the lowest EV/EBITDA valuations for telecoms among other industries. As revenue increase is limited due to uncertain data monetization and lack-of killer applications, operational and capital expenditures (OPEX and CAPEX) have to be actively managed by operators. Therefore cost efficiency received considerable critical attention recently.

Structure. This paper has been divided into six parts. The first, introduction part deals with the research question and hypothesis, then with the explanatory drivers, as demand side of mobile network, technology enablers of cost efficiency initiatives and the savings opportunities focusing on MNO-Hyperscaler collaborations. In the second part the literature review will focus on assessment of key regulatory concerns and consultancy recommendations. The third part will cover the description of qualitative and quantitative research methodology. In the fourth, discussion part financial impacts of virtualization and co-investments will be covered, as well as show key rival and incumbent MNO strategies and incentives for Hyperscaler cooperation. The fifth, results chapter highlights the key financial impacts and the final, conclusion part presents the relevance of indirect financing via Hyperscaler co-investment model, and its potential attribution to cooperation in physical infrastructure.

Research Question. The research question seeks to address the question of what is the optimal form to promote Hyperscalers' financial contribution to 5G rollout? Clarifying that the role of Hyperscalers is gaining more importance, as their business growing by much higher pace, than MNOs business and their content-services have more powerful impact on whole value-chain financials.
The Hypothesis tested is the direct financial contribution, perceived an optimal cooperation form, claimed by many operators and politicians.
In order to make a full assessment on research question the following preconditions have to be taken into consideration.

Demand Side. Investments into more technology and spectrum efficient mobile network generations (in particular move from 4G to 5G) is already driven by customer demand, represented by traffic increase nowadays. Ericsson states, that the average mobile data consumption reached 11.4 GB/month/mobile users in 2021 and predicts CAGR 24% growth from 2021 till 2027. MNOs were struggling to identify killer applications for decades, however Over-The-Top (OTT) players, named BigTechs or Hypersclares recently managed to provide attractive content and services. Based on Sandvine reports the global internet traffic (includes both mobile and fixed, latter carries dominant part of traffic) is driven by video, gaming and social media upto 80%. Latest report published in May 2021, displayed the traffic in application category and even at application

level (Cantor and Cullen 2021). Table 1 illustrates that 96% percentage of downstream traffic related to TOP6 application categories that is a really high concentration. In 2020 lockdown during the worldwide stay at home, YouTube generated 15%, Netflix 11% of total global traffic (Table 2).

Table 1. Global application category traffic share.

Ranking	Application Category	Downstream	Upstream
1	**Video Streaming**	49%	19%
2	**Social Networking**	19%	17%
3	**Web**	13%	23%
4	**Messaging**	7%	20%
5	**Gaming**	4%	2%
6	**Marketplace**	4%	2%

Table 2. Global application traffic share.

Ranking	Application	Downstream	Upstream
1	**YouTube**	20%	4%
2	**Facebook Video**	11%	3%
3	**TikTok**	7%	3%
4	**Facebook**	6%	2%
5	**Google**	5%	1%
6	**Instagram**	5%	1%

These application categories and applications are triggered by Hyperscalers, who are monetizing indeed the mobile network without contributing to the investment burden.

The customer demand has three key-attributes that will gain importance first in business then in consumer customer segments: (a), capacity, described by enhanced mobile broadband (eMBB) use cases, (b) reliability, the ultra-reliable low-latency communications (uRLLC) capability use cases, (c) capability to handle large amount of tools, the massive machine-type communication (mMTC) use cases.

Overall from demand side these factors have the largest impact on technology development directions.

Technology Enablers. What we see in technology development is far more that we got used to in previous network swaps or introduction of 4G top on 3G or even 3G top on 2G. A technology shift is going to happen towards creative destruction (disruptive technologies) by network disaggregation, virtualization and open RAN. The "monolithic telecom infrastructure based on proprietary hardware and closed interfaces" (Taga and

Virag 2021) turn to disaggregated (HW-SW) and open (multi-vendor selection) Radio Access Network (RAN) and Core Network. The legacy network failed to provide the flexibility, scalability and degree of automation. The key element of the new direction is virtualization, cloudification, softwerization that enables end to end software-defined networks (SDN), virtual network functions (VNF), cloud native, cloud edge computing, public-cloud scale, artificial intelligence (AI) driven automation and machine learning (ML).

Fields of HW & SW disaggregation, network function virtualization and containerization allow for radical architectural changes across mobile network RAN and Core domains. Virtualized network aims to put the functionality of customized equipment into software programs that run on commercial off-the-shelf (COTS) servers. In RAN domain radio signal processing can be done in the cloud. Base stations are smaller and simpler than those deployed in traditional networks, because there is no need for specialized hardware to process voice calls and data requests. Instead, the base stations simply send signals from individual devices to software in the cloud for processing. SDN and VNF allow for the scalability and automation required for future 5G use cases. Edge and far-edge data centers (DC) allow the deployment of VNFs close to the customer, reducing latency, improving quality of experience (QoE).

AI role to optimize the use of radio spectrum, including by training algorithms which are able to adapt parts of the network to specific conditions, like a large storm or concert and web-scale refers to a flexible service for robustness that can scale and add new services quickly, like a public cloud network in Core domain.

Majority of these network capabilities require to exceed currently widespread 5G non- standalone (NSA) RAN and Core networks. 5G standalone (SA) architecture is the enabler of network slicing, which is a kind of "on user-demand logical separated network partitioning, software-defined on-top of our common physical network infrastructure" (Kyllesbech 2022).

Ericsson and Arthur D. Little consultancies published a study on network slicing opportunities and revenue potential for MNOs and one of the main findings was that listed demands (eMBB, URLLC, mMTTC standard Slice Service Types, defined by GSMA and ITU) can not be served without network slicing in more than 30% of 5G use cases explored. "The diversity of requirements will only grow more disparate between use cases—the one-size-fits all approach to wireless connectivity will no longer suffice." (Network slicing…, 2021).

Overall, the innovations in RAN and Core domains indicates a reconfiguration of the existing market structure and facilitates the entry of companies that are specialized in single elements. These solutions fostering vendor diversity, increasing the development speed and competition. Market entry enabled by technologies are in particular relevant for Public Cloud service Providers (PCPs), covering Hyperscalers also to make co-investments with MNOs in the 5G Communication Service Providers (CSPs) market.

Cost Efficiency and Co-investment Models. Although 5G brings technology efficiency at unit GB cost level, economic cost efficient, sustainable and green operational excellence initiatives also required from MNO side to limit TCO increase, promote higher coverage and capacity, and allow continuously more affordable consumer prices.

Technology development is the enabling factor of new and cost efficient business models, where savings coming from (i) operator-operator collaboration, like horizontal agreements (Network Sharing) and asset reconfiguration and monetization (spin-off TowerCos and FiberCos), (ii) operator-vendor relationship reassessment with virtualized and open RAN (multi-vendor model), and (iii) operator-Hyperscalers relationship set-up enabled by cloudification of Core and RAN (public cloud providers), addressing the issue that Hyperscalers driving and monetizing GB data growth, however not contributing to infrastructure investments.

In this paper I would like to cover the assessment of MNO-Hyperscaler cost efficiency initiative from corporate finance and regulatory aspects.

Hyperscalers are those companies that offer networking, cloud and internet services with an established data center footprint. In the context of this study it primarily referring to public cloud providers. Largest players are Amazon Web Service (AWS), Microsft Azure and Google Cloud, subsidiaries of Big Tech conglomerates, owning much higher corporate valuations and revenue growth rates, than MNOs. Also significant public cloud service providers are Oracle, IBM, Alibaba, Baidu and Tencent Clouds. Hyperscalers have already for public cloud the network-centric tools (e.g.: edge computing, AI/ML analytics) and services. Due to these capabilities, MNOs consider partnering with Hyperscalers to improve cost efficiency both in CAPEX and OPEX.

2 Literature Review

A large and growing body of literature has investigated the cooperative investment (co-investment) topic, however there is a significant decrease on journal articles from fixed towards mobile, in particular to Hyperscaler subcategory.

The majority of previous studies deal with Fiber to the Home (FTTH) co-investment impact on fixed broadband internet rollout. The study of Aimene L. et al. carried out that in the French market the co-investment partnership of Orange incumbent operator and alternative providers could increase the FTTH adoption and also promote competition by lowering incumbent operator's market share. (Aimene et al. 2021).

A lower number of studies postulated co-investment in mobile segment. A recent study has argued on co-investment benefits, as infrastructure sharing agreements can decrease prices, increase consumer surplus and subscriptions (Jeanjean 2021). Another study revealed from competition policy aspects that mobile network sharing related potential harms are not jeopardizing the competition at retail market (Pápai et al. 2020).

Surprisingly very few journals conduct on Hyperscaler related co-investment opportunities. An ITU study indicated how far OTTs contribute to MNO revenue, what is the optimal form of OTTs and network operators co-investing, as data traffic accounts for a significant share of network costs. (Kettani et al. 2020).

Another study discussed the role of content providers in ultra-fast broadband access networks. It starts from network neutrality (NN) regulation of the Internet, and the question is how an Internet Service Provider (ISP) can negotiate with the content provider (CP) a fee for (priority) delivery of content and affects firms' investment incentives. The study shows that the CP might be more willing to co-invest if NN regulation were removed to avoid high ex post fees. (D'Annunzio and Reverberi 2016).

The originality of this paper that it is among the first papers at journal level shows the significance of Hyperscaler co-investment. In consultancy and business materials considerable amount of literature has been published related to concerns of Hyperscalers' market power and the necessity of regulation. However, there are relatively few studies available in the area how to resolve this interest of conflict and populate Hyperscalers into the mobile service value chain to financially contribute to 5G deployment, relieving investment burden from MNOs.

The two different approaches represented best by the appeals of regulators and recommendations of consultancies. At the section end MNOs' standpoints also introduced.

Regulation. European competition and sector regulator authorities raise concerns against mainly US based Hyperscalers.

Competition Regulation. Margrethe Vestager, EU Commissioner for Competition urged European regulators and legislators on a Financial Times conference to finalize Digital Markets Act (DMA) and the Digital Services Act (DSA) in order to curb the power of Big Techs (Espinoza 2021).

The purpose of DMA to force Hyperscalers to ensure more equal terms on their online platforms. It would affect companies with a market capitalization of at least 80bn EUR (e.g. Google, Amazon, Apple, Facebook and Microsoft) and prohibit Big Techs from ranking its own services beyond their rivals. The DSA created to clarify the way large online companies should keep illegal content off their platforms.

Summing up, the competition policy related aspects covering rather the content relevant parts and not addressing direct strategic and financial concerns.

Sector Regulation. The Body of European Regulators for Electronic Communication (BEREC) started the investigation of openRAN topic in wireless network evolution workgroup. The first published material drew 4 scenarios for most realistic developments of the 5G equipment and services supply market till 2030 (5G supply…, 2021). The study analyzed economic, technological, environmental, and social impacts for each scenario, covering key European Commission and stakeholder concerns, including market competition, costs (OPEX & CAPEX) requirements. The identified scenarios are (i) incumbent players driving 5G, (ii) slow pace of 5G rollout, (iii) open RAN as a game changer, (iiii) 5G for Big Techs.

Out of 4 scenarios, the Big Techs is relevant for this paper. Assumed storyline is that Big Techs conquer the 5G supply markets with open RAN business models, as virtualization of networks and disaggregation of software change the landscape. As software can be run on someone else's physical infrastructure, the use of clouds becomes more commonplace. Companies from vertical industries are encouraged to enter the 5G supply market. MNOs are not able to find their role as infrastructure providers for industrial players and might be overcome by Big Tech companies who also offer services to end-users. Big Techs become the "new operators" by offering carrier-like services bypassing incumbent mobile network operators and end-user connections. Thus, Big Tech companies will serve as virtual operators and increase their overall dominance in the market. Summing-up Big Tech companies may leverage their cloud and software capabilities to move into connectivity and supply domains with innovative solutions and their financial strength allows them to overtake existing players and new entrants. For Big Techs the Core network might be more relevant at first, than the RAN. Because the it

is easier centralized, and closer to their current skills and infrastructure, based on cloud computing in data centers.

From Market competition perspective, there is a risk that value-add will shift from connectivity to the cloud, and MNOs' value generation may decline. Hyperscalers dominate the end-user services by offering more value-added OTT services, and MNOs remain stuck offering the least profitable part of the chain (i.e. "dumb" pipelines). Finally, Big Techs may enter into the connectivity provision market and increase competition.

Regarding cost efficiency, the study suggests that the impact on RAN-related OPEX is low. Hyperscalers take over a small part of a base station's processing, and reserving higher bargaining power and overall dominance to keep their solutions's prices high.

From US Federal Communications Commission (FCC) side a Commissioner argued, that "Big Tech has been enjoying a free ride on our internet infrastructure while skipping out in costs needed to maintain and build that network". (Carr 2021).

This statement is in line with European concerns, however formulated on a more straightforward way.

Overall the regulatory studies and statements highlighted the concerns regarding Hyperscalres entrance into telecommunication market, and put much less emphasis on potential upsides of MNO-Hyperscaler cooperation.

Consultancies. Leading technology, media and telecom (TMT) sector consultancies, like Analysys Mason, Arthur D. Little and Dell'Oro Group embrace the idea of MNO-Hyperscaler cooperation is value generating and lucrative for both parties, also addressing the question how to involve Hyperscalers into funding of 5G implementation.

Recent Analysys Mason (AM) study has conducted that MNOs should consider partnering with Hyperscalers to improve CAPEX efficiency (Brown 2021). AM suggests to set-up co-investment partnership to relieve CAPEX pressure of 5G rollout, in particular till SA rollout arrives. It also covers mainly the same co-investment models, listed in this study previously and focus on Hyperscalers cooperation scenario. AM concerns that MNOs can use third-party cloud infrastructure to support cloud-native networks and reduce CAPEX associated with building their own (telco) cloud, as Hyperscalers already have the expertise on such NW capabilities like, SDN, VNF AI/ML, edge computing and data centers. However, Brown drew attention, that "Operators must balance the benefits of Hyperscaler partnerships with the risk of losing control of the network". Overall AM recommends MNOs to assess the entry of Hyperscalers into the telecoms as an opportunity to improve CAPEX efficiency and network capabilities, as well as scale up their new networks more rapidly than they could otherwise do alone (telco cloud). Mainly Hyperscalers as new investors will not seek to challenge established MNOs in their core business (at least currently), but will be targeting a role in a value chain, transformed by cloudification.

Athur D. Little (ADL) has published a study, emphasizing the importance of virtualizing mobile networks (Taga and Virag 2021). The material offers an in-depth insight into open RAN radical architectural changes across RAN and Core domains, containing disaggregation, centralization, virtualization with multivendor model. It demonstrates the Time to Market (TTM) and customer experience (CEX) impact of Open RAN reducing lead time from weeks to hours/minutes with zero-touch operation. It also found upto

30–40% cost efficiency improvement in both OPEX and CAPEX, however these findings related to the whole ecosystem change, while Hyperscaler and MNO cooperation is just one part of it.

Dell'Oro Group draws the distinction between private (telco) and public cloud in order to demonstrate ideal partnership between MNOs and Hyperscalers (see Fig. 1, Bolan 2021b).

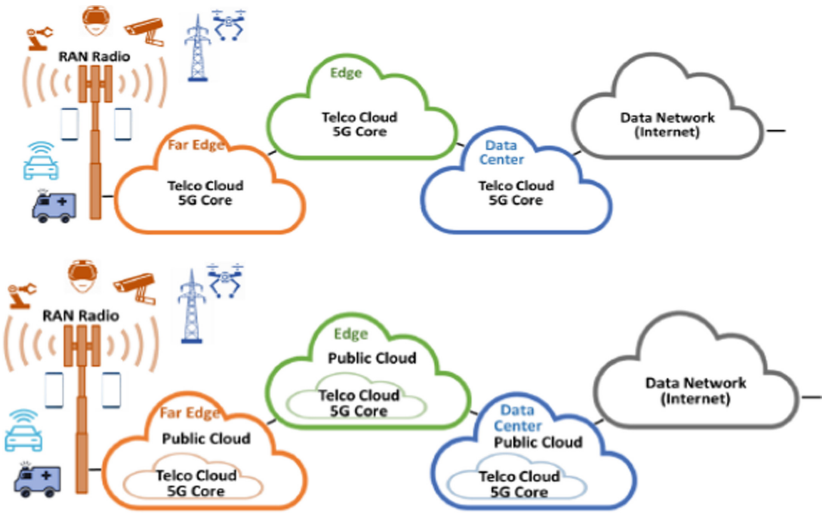

Fig. 1. Overview on Telco vs Public cloud (Bolan 2021b).

The importance of the study to explore several cooperation forms of MNO-Hyperscaler co-investments. MNOs can develop their own telco cloud however, it might be very costly to set-up cloud functionalities from scratch. As 5G networks move into the cloud, it becomes viable for Public Cloud SPs to host the 5G CSPs networks and it extends many benefits to the MNOs beyond lowering costs. Integration can be carried out via either Public Cloud SP Services go into 5G CSP Networks or Public Cloud SPs host 5G CSP Networks. Further importance of this study the listing of Public Cloud Computing advantages in terms of cost, speed, scalability, performance and productivity (Bolan 2021a).

MNO Statement. Thirteen European MNOs, member of European Telecommunications Network operators' association (ETNO) urged action from policymakers to provide a competition policy allowing operators to build the necessary scale to realize the EU's digital decade 2030 ambitions, so Europe's competition policy need to balance between investment as well as competition. (Joint CEO…, 2021).

The CEO statement raised the question on how to balance the interests of Big Techs and MNOs. Global tech players "generate and monetize" a "large and increasing part" of network traffic, which "requires continuous, intensive network investment and planning by the telecommunications sector". This can "can only be sustainable if such big tech platforms also contribute fairly to network costs", concluded the statement.

In US, similar argumentations were taken by AT&T and other ISPs over the past 15 years, that Big Techs delivering content over the Internet get a "free" ride and should subsidize the cost of building last-mile networks in Fixed line segment.

One more relevant concern raised by BT that argues for modification of net neutrality rules that stipulate the treatment of all Internet traffic equally. This rule might be considered outdated for the streaming area or 5G SA network slicing attempts, in which user-demand logic based service level combinations (differentiation service level for different prices, e.g. Latency, reliability, availability, coverage) will be offered.

Overall these studies highlight the need for conflict resolution between MNOs and Hyperscalers. Regulators revealed fairly the imbedded risk of Big Techs, that have to be mitigated and MNOs claim is valid that Hyerpscalers should contribute to network developments, but the cloudifications brings the proper, market conform role, where Hyperscalers can step into the value chain as a co-investing partner.

3 Research Methodology

The current study puts the "creative destruction" into the centre of management theories applied. Creative destruction is most often used to describe disruptive technologies such as openRAN with disaggregation, virtualization and cloudification with edge-computing that in-depth change the telecommunication landscape.

Josef Schumpeter in 1942 in Capitalism, Socialism, and Democracy book characterized creative destruction as innovations in the manufacturing process that increase productivity. "The opening up of new markets, foreign or domestic, and the organizational development from the craft shop and factory to such concerns"- illustrate the same process of industrial mutation – „that incessantly revolutionizes the economic structure from within, incessantly destroying the old one, incessantly creating a new one. This process of creative destruction is the essential fact about capitalism." (Schumpeter 2011).

Summing up, from economics point of view creative destruction describers the upcoming technological shift, where many players, including MNOs and Hyperscalers are repositioning their role.

This study employs a mixed methods approach, built on both qualitative and quantitative empirical data analysis. With regard to the research methods, some limitations need to be acknowledged, as this study covers such forward-looking, pioneer topic, in which application of actual data are limited, not only for openRAN, but in particular for public cloud economics.

Therefore, the main qualitative research method adopted to gain detailed understanding of key stakeholders' (MNOs, Hyperscalers and Regulators, covered already in Literature review chapter) market behaviour.

The limited quantitative empirical analysis can be carried-out on small size of dataset, mainly based on consultancies and vendors prognoses. Even though the relatively limited sample dataset, this study offers valuable insights into financial and competition assessment relevant considerations of MNOs and Hyperscalers cooperation.

4 Discussion

This chapter provides in-depth analysis of the market developments. The aim to present key forecasts on virtual and open RAN widespread and within trend, report public cloud evolution and the key cooperation between Hypersclaers and MNOs, divided them into challenger and incumbent operators.

Market Trend of Open RAN. Analysys Mason consultancy estimates as a mid-case (middle income countries, moderate take-up) for open RAN adoption of the market, that 54% of subscribers will be served by open RAN networks at the end of 2030. In case of slow take-up scenario 26%, in case of fast take -up scenario 86% is the relevant subscriber rate. In low income countries the growth can be a little been even higher due to higher openness for cost efficient solutions. (Abecassis et al. 2021). At investment side Rethink Technology research estimates that 58% of total RAN CAPEX and 65% of deployed sites could be openRAN related in 2026. (Everything…, 2021).

Market Trend of Communication and Public Cloud Service Providers Partnership. Over 34 partnerships have been established between MNOs and Hyperscalers as of July 2021 based on Analysys Mason to set-up a co-investment in public cloud for virtualized RAN or Core. (Brown 2021).

Challenger Communication Service Providers (MNOs). Challenger operators mainly new entrants into the matured market, who would like grab a remarkable market share. Although they might have an advantage not to build out 2-3-4G, just focus on 5G and new technologies, they suffer from front investment burden and lack of scale in short and mid-run operation. Nobuyuki Uchida, an executive at Rakuten's mobile unit told that "We came to the conclusion that we wouldn't be able to compete if we operated in the same way as the rest of the industry." (Fujikawa 2021), therefore disruptive technologies (creative destruction) like disaggregated and virtualized open RAN or MNO-Hyperscaler partnership required to increase cost efficiency (productivity) as Schumpeter stated.

Rakuten. One of the most significant trials related to Rakuten's break into the Japan market with a cloud-based wireless network. Rakuten is building Japan's fourth nationwide wireless network and has begun to offer 5G services. It virtualizes and operates through the cloud both RAN and Core parts of a mobile network. Rakuten says maintenance costs are lower in a software-driven network, because updates can be done remotely and all at once, rather than individually at base stations. Rakuten estimates 40% CAPEX savings on the cost of building out its network and 30% OPEX savings in operation. However, Rakuten rather than outsourcing to public cloud, has built its own telco cloud, and launched a subsidiary, called Rakuten Symphony, to offer the system to other operators, and via wholesale model to increase scale and achieve better return.

Dish. US based Dish planned to become a fourth national player for mobile services from previous mainly satellite-TV provider position. Dish plans to introduce a 5G network running on public cloud, operated by Amazon Web Services (AWS). Dish's network is to be the first in US that would live almost entirely in a computing public cloud, except for antennas and cables in slender boxes attached to antenna posts. These

are connected directly to the AWS cloud, which hosts the virtual part of the network. Therefore Dish's fully automated network intend to be cheaper to set up and operate.

1&1 Drillisch. The German 1&1, currently Mobile Virtual Network Operator (MVNO) reported to enter into the market as fourth MNO and made a long term agreement with Rakuten to design, maintain and operate open RAN network on fully virtualized Rakuten Communication Platform (RCP).

Incumbent MNOs. Incumbent operators are adopting cloud-based technology too, but often more cautiously. The mainstream market continued to source virtualized networks from traditional suppliers in the form of pre-integrated single vendor stacks. However, the lack of interoperability between vendors' solutions created cloud-based silos.

AT&T. Many large, advanced operators, including AT&T, attempted to build their own, multi-vendor network (telco) cloud platforms, but they ran into major integration, orchestration and automation complexities and costs. (Yigit 2021).

However, in the middle of 2021 AT&T made the decision to outsource its 5G Core network to Microsoft Azure, which is a landmark decision and provides an example of a future role that Hyperscalers may take to support telecoms networks. Analysys Mason underline the significance of pioneer role of the decision: "AT&T's decision to outsource its 5G mobile network cloud to Microsoft will act as a catalyst for the adoption of public cloud provider (PCP) cloud stacks by other operators." (Yigit 2021).

AT&T will benefit from Azure's cloud expertise and scale, and will target improved QoS, as well as aiming to reduce costs. However, this partnership means that AT&T having less influence in the running of the network. This might be a CAPEX relief for AT&T to invest into other areas of its business, but it leaves the company at risk of losing control of some critical asset (Will the…, 2022).

Other MNOs. Other incumbent players also set-up co-investment partnerships with Hyperscalers to support certain goals, but mainly focusing on smaller scope, like core domain or private networks customer segment. Telefónica expanded its strategic alliance with Microsoft to deliver confidential hybrid cloud solutions to public administrations and regulated sectors. Telenor formed a partnership with Google cloud to explore how to leverage Google Cloud's expertise in data management, AI and ML and later partnered with Amazon Web Services (AWS) to speed up the modernization of its telecoms systems. Swisscom published an 5G core announcements with AWS also.

What emerges from these results reported here, MNO and Hyperscalers co-investment has started in rival MNO segment, followed by incumbents, but it is still a question, whether will collide the two huge industries and whether cloud business might jeopardise telecom industry or a balanced mutual advantageous partnership can be set-up.

5 Results

The aim of this chapter that based on key corporate financial trends, justify the necessity of cost efficient, co-investment solutions in 5G rollout and reveal the savings potential from MNO-Hyperscaler cooperation. The numeric quantitative analysis conducted on limited financial information, mainly from consultancy forecasts.

As mentioned in the literature review and discussion parts, OPEX, CAPEX, altogether Total Cost of Ownership (TCO) efficiency is required to achieve a satisfactory return on investment for 5G deployments. The following financial trends summarized from Analysys Mason consultancy and GSMA (Global System for Mobile Communications) forecasts.

OPEX. The operational cost at total telco company level globally expected slightly decrease between 2020–2027, however Network related spending forecasted to have a minor increase both nominal and proportion level (from 48% to 53%) based on Analysys Mason (Venturelli et al. 2021). The moderate increase in NW spending assumes adopting tremendous cost efficiency efforts to minimize increase from customer demand led coverage, capacity and capability investments.

CAPEX. As many consultancies, Analysys Mason also indicates that due to cost efficiency initiatives current CAPEX level can be capped.

Total CAPEX. Telecoms CAPEX will be 22% lower in 2027 than in 2019, despite new investments drop by cloud migration. (Goldman 2021) The 5G investment curve will significantly differ from 3 or 4G investment period. It will last much longer (4–6 years), without a 1–2 years peak period.

The 5G related CAPEX will reach 62% of total telco company (wireline and wireless) level in 2027 compared to 40% in 2021. (Goldman 2021).

RAN CAPEX share. GSMA estimated that RAN and Core CAPEX will slightly increase and RAN share will grow to 87% in 2025 from 82% in 2021. (Yuen 2021).

Vendor Related CAPEX Share. AM found that the CAPEX decrease is thank to decreasing MNOs' own, in-house developments and relying more on external service providers, integrators and platforms. AM argues MNOs will only achieve the cost efficiencies if they reduce their number of in-house developments as these are customized solutions that are hard to keep up-to-date and less scalable.

Vendor CAPEX share will go up to 73% in 2027 from 60% in 2017 contrast to inhouse developments. Per domain the higher increases expected in RAN to 72% from 50%, Core to 90% from 79% and IT and Cloud to 85% from 71%. (Goldman 2021).

Virtualization Share: AM study reports that despite of total CAPEX decrease expected, the virtualization relevant CAPEX domains will increase by upto 36% CAGR 2017–2027. AM prediction for increase is 36% in vRAN SW and services, 32% in vRAN cloud and radio units, 17% in SDN, soft switching and routing, 13% in cloud infrastructure, SW and edge. (Goldman 2021).

Public Cloud. The migration to public cloud from in-house developed telco cloud driven by TCO savings expectation. The adoption of cloud-based and software-centric architecture will help operators to build out significantly more network capacity than in the 4G area for the same CAPEX. MNOs end goal is "zero-touch" operations, enabling significant OPEX reductions and better real-time optimization of network performance. OPEX are lower in a software-driven network, because updates can be done remotely and all at once, rather than individually at base stations.

Therefore Analysis Mason estimated at least 25% savings potential at TCO level compared to own telco cloud development. (Gabriel and Venturelli 2022).

Summing up key financial trends conducted, the following Fig. 2. Contains the main levers.

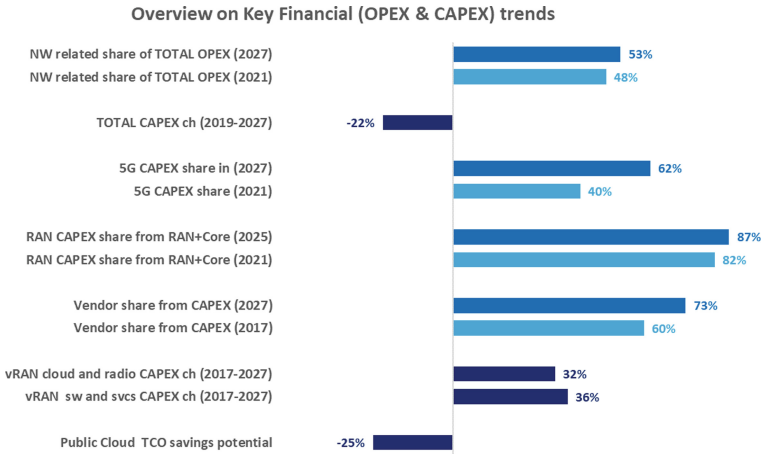

Fig. 2. Overview on Key financial (OPEX& CAPEX) trends (own statement).

6 Conclusion

Overall, the results indicate that there is a market conform, mutual beneficiary resolution for contribution of Hyperscalers to MNO investments, triggered by Hyperscalers services. Virtualization in disaggregated RAN and Core networks and Public Cloud is the direction, where telecom and Big Tech sectors get closer eachother and can set-up co-investments.

Qualitative analysis on conduct of MNOs in previous chapter demonstrates that both virtualization and public cloud are on the MNOs' agenda. Challenger telcos, striving for productivity advantage from out of-box, disruptive technologies to beat incumbents, therefore has become the pioneers in virtualization and public cloud trials. Incumbents to avoid getting into a backlog, has become opened for creative destruction to preserve their market dominance and overcome complexity in a cost efficient way, coming from their long time operation.

Quantitative analysis of consultancies' forecasted OPEX, CAPEX trends revealed that in order to limit Network TCO, cost efficiency initiatives have to be launched. Higher spending for standardized vendor solutions and virtual technologies in key domains can promote OPEX and CAPEX savings, in case of Public Cloud at least 25% TCO savings can be reached.

What emerges from this study that MNO and Hyperscaler co-investment is a feasible and viable resolution at first stage for better and more fair cooperation, however, MNOs must weigh up carefully the risks and benefits when considering partnerships with Hyperscalers. So original Hypothesis fails, direct market intervention is not necessary on the current market.

Potential Future scope might be the competition impact assessment of virtualized and open RAN with Public cloud in a network slicing capable 5G standalone network to physical infrastructure based cooperation, like Mobile Network Sharing as well as TowerCO carve-outs and mergers, that currently under strict conditions approved or even refused by National Competition Authorities.

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