Efficiency and Effectiveness of Net Neutrality Rules in the Mobile Sector: Relevant Developments and State of the Empirical Literature

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Abstract

The net neutrality debate, spanning about two decades, has recently undergone revisions in the EU and the UK and encountered divergent policies in the US. These rules significantly influence market power in the ICT ecosystem, shaped by fundamental changes since sector-specific regulation in the EU and the origin of the net neutrality debate in the US in the early 2000s. Notably, there is limited empirical research on the economic impact of net neutrality rules, representing a substantial ex-ante market intervention with uncertain effects towards main market actors. Focusing on the mobile sector, we examine the effectiveness of net neutrality rules in light of key technological and regulatory developments, and the efficiency of net neutrality rules in light of the empirical literature and provide some descriptive evidence on some key mobile broadband policy variables. We find that net neutrality regulation is likely to be inefficient, implying negative welfare effects, even more so when the total regulatory costs are taken into account. In contrast, neither empirical nor anecdotal evidence from trends supports the arguments of proponents. Moreover, we find that net neutrality policies imposed on only one segment of the Internet value chain have become increasingly ineffective and EU-style net neutrality regulations will lead to substantial market uncertainties regarding 5G-based services and applications. The recommendation is that providers of broadband internet access services should be given more options for pricing and quality design, subject to established ex-post competition law as well as existing sectoral transparency and end-user protections. Alternatively, regulators could consider a principles-based framework subject to a limited scope of ex-ante obligations. Finally, to meet the substantial investment needs for widespread 5G and fibre-based broadband deployment, policy-makers should explore complementary funding models to proportionately include contributions from other market actors who benefit from the network infrastructure.

1 Introduction

The debate about net neutrality on the Internet has been ongoing for about two decades and was initiated in academic circles with the contributions of law professor Tim Wu in 2002. Wu was a strong advocate of Internet regulation and is credited with coining the term "net neutrality" and laying the foundation for the underlying narrative that the legal establishment of binding rules of conduct for ISPs is essential to achieve the goal of an open and non-discriminatory Internet (Wu, 2002, 2003). In particular, the following key principles have been identified as essential in the net neutrality debate: all Internet traffic should be treated without (i) discrimination, (ii) blocking, and (iii) throttling or prioritization; moreover, (iv) a zero-price rule prohibits an ISP from charging a CP a “termination fee” to send data in wireline or wireless “last-mile” access networks to consumers.

Historically, the concept of net neutrality has been based on a "best effort" principle, meaning that all packets are treated equally on the Internet, which was originally designed for non-time-sensitive applications. Proponents of net neutrality argue that this is the only way to prevent ISPs from exploiting their "gatekeeper" position in local access markets to discriminate against unaffiliated content and application service providers. They further argue that net neutrality rules would ensure the openness of the Internet, promote innovation and ensure consumer choice, which would in turn lead to investment in broadband infrastructure, creating a virtuous circle. In the years that followed, the concept of net neutrality became the subject of hard-fought and – for an ICT topic unusually ideologically driven – debate that continues to this day. While proponents continue to call for the imposition of net neutrality regulation, opponents of such regulatory intervention argue that it has become increasingly ineffective and also detrimental to welfare in the long run by reducing the profitability and investment incentives of ISPs (Briglauer et al. 2022). Opponents further argue that former market dominance driven gatekeeping positions in local access markets disappeared due to intense infrastructure-based competition. In contrast, a small number of CPs have increased their market position and criticality to end-users to point where it is not feasible for telcos to not carry or otherwise degrade their content. Therefore, even if permitted, intense retail competition would by and large constrain ISPs in engaging in e.g. blocking, or throttling practices.

The net neutrality regulation, adopted by the European Commission in its Open Internet Regulation (OIR; European Commission, 2015), aims to protect end-users while ensuring the continued functioning of the internet ecosystem through the above-mentioned conduct rules. Exceptions to the EU's strict net neutrality rules are allowed for “reasonable traffic management”. In managed networks, ISPs can apply differential treatment to different categories of traffic where there is an objective technical justification to do so, although this cannot be monetized. They are

also able to commercially offer so-called "specialised services", where connectivity is optimised for the needs of specific applications, such as IPTV, VoLTE, videoconferencing or real-time health services. Enforcing these net neutrality rules is an important task for national regulators, who should follow the guidelines initially adopted by the Body of European Regulators for Electronic Communications (BEREC) in August 2016 and most recently updated in 2022 (BEREC, 2016, 2022). Similar regulations exist in other non-European countries and existed in the US until 2017/2018. In the US, they were formally repealed in 2017, and in June 2018 the "Restoring Internet Freedom Order" was enacted (FCC, 2018). Net neutrality regulations in the US and the EU have therefore been similar in design but have followed different trajectories. In both jurisdictions, strict net neutrality regulations were formally introduced in 2015. In the US however, the legal position has not been static. Whereas the strict regulatory net neutrality regime in the US was introduced during the democratic-led Obama presidency, the regime was repealed under the republican-led Trump presidency. Therefore, the regulatory regime in the US has since 2017 been fundamentally different from the strict regulations still in place in the EU. However, after the US elections in 2020, the new Democratic chair of the Federal Communications Commission (FCC), Jessica Rosenworcel, made an early commitment to reinstate 2015-style net neutrality rules. However, it took until October 2023 for the FCC to muster the necessary majority and vote to begin a process to reverse the existing policy of no net neutrality rules.[1]

Despite the fundamental policy changes in international comparison (Garrett et al., 2022) and the high degree of market intervention embedded in net neutrality regulations, there is little empirical research on their actual economic impact. This is remarkable, as net neutrality regulation represents a strong form of market intervention with unknown welfare effects for the main economic actors in the internet ecosystem (CPs, ISPs and consumers/end-users) and high implementation, monitoring and enforcement costs. Given these developments, the contentious and often ideologically charged debate over the past two decades, and the limited empirical evidence available, our aim is to provide a fresh assessment of the impact of net neutrality rules in terms of their effectiveness and efficiency properties, with a specific focus on mobile broadband networks. In doing so, we aim to address the following research questions: (i) What do recent technological and regulatory developments imply for the effectiveness of net neutrality regulation? (ii) What are the main findings of the available empirical literature on the effects of net neutrality regulation? (iii) What is the descriptive evidence on the impact of different net neutrality policies in the US and the EU?

[1] Information available at: https://www.fcc.gov/document/fcc-start-proceeding-reestablishing-open-internet-protections.

Addressing these research questions should significantly enhance the policy discussions in Europe, the US and other developed countries. This is particularly important in the context of the ongoing deployment of the new 5G mobile network technology, which not only offers faster speeds, greater capacity, and lower latency than previous mobile broadband technologies but also introduces virtual networks and network slicing, which, given their ability to support differentiated connectivity experiences, may come into conflict with strict network neutrality regulations. The dynamic and adaptive network management associated with 5G requires a reassessment of the current network neutrality framework in the EU and other national jurisdictions, including the interpretation of exemptions for reasonable traffic management and specialized services (Yoo, 2023). Moreover, a large number of future IoT applications and devices also have service-specific quality requirements and might thus have to be considered as specialized services as well.

Our paper is structured as follows: In Section 2, we begin by outlining the broader institutional context of the net neutrality debate, which includes alternative funding models for the high investment requirements associated with rapidly increasing traffic in ISP networks. In Section 3 we then describe a number of key technological and regulatory developments shaping the actual scope and effectiveness of net neutrality regulation. In Section 4, we review the relevant literature, focusing on all available empirical contributions on the causal effects of net neutrality regulation on key economic policy variables. In Section 5, we complement the empirical evidence with some descriptive analysis, contrasting recent developments in EU mobile broadband markets with the situation in the US and other jurisdictions with opposing net neutrality policies compared to the EU. Our final Section 6 summarizes and outlines the main policy recommendations for the ongoing policy debate.

2 Institutional background

The ICT ecosystem has evolved considerably since the beginning of sector-specific regulation of electronic communications markets in the EU in the early 2000s. In today's broadband-centric internet ecosystem, large content providers (CPs) such as Microsoft or FAANG companies (Facebook (now Meta Platforms), Amazon, Apple, Netflix, and Google (now Alphabet)), have significantly challenged traditional industry structures and the former large telecom operators. Today, large CPs not only provide popular content but also transport a large part of Internet traffic to end users, as they also own global server networks, some of which are interconnected via private global network infrastructures. These changes in ICT ecosystems are also accompanied by fundamental shifts in market power. In the “old” telecom world, so-called incumbent telecom operators such as AT&T, Deutsche Telekom or Telefonica have long enjoyed a strong and legacy infrastructure-based position of market dominance in pre-defined electronic communications

markets;[2] these telecom operators ("telcos") and other broadband access Internet service providers (both hereafter referred to as ISPs) now face very strong bargaining power from CPs derived from the demand side due to the high popularity of their applications and services among end-users. These drastic shifts in market power within the ICT ecosystem are also clearly reflected in the evolution of market capitalisation: In November 2023, the 164 largest European ISPs (telecommunications companies) currently have a total market capitalisation of around USD 1.79 trillion, which is far less than the total market capitalisation of the six US technology giants FAANG+Microsoft of around USD 10.146 trillion.[3] The dynamism of this development is also remarkable in that most of these and other CPs were only established after the early phase of telecommunications market regulation some 15-20 years ago. At the same time, the profitability patterns that underpin the market capitalisation must be contrasted with the continuing high investment requirements and declining or stagnating revenues on side of the ISPs. While average revenues per user in the fixed-line sector has stagnated at a level of around €21.9 per month over the past decade, there has been a gradual decline in the mobile sector from €16.2 to €14.6 per month (ETNO, 2023, p. 38). The decline in revenues in the sector is tied to a number of factors, underpinned by the sector specific regulatory framework and competition. This includes the replacement of traditional telco services for certain CP´s communications services, such as MS Teams, Whatsapp, Facetime which are available at no extra (monetary) cost to consumers. This has led to increased data traffic on telco networks, whilst average revenues have simultaneously shrunk in mobile networks.

According to the European Commission (EC), additional investment of up to €200 billion is needed to ensure full gigabit coverage across the European Union (EU), as well as 5G coverage in all populated areas.[4] The EC also notes that investment in the EU is lower than in its main trading

[2] The term incumbent refers to former typically state-owned and fully integrated telecommunications operators who were deemed to have significant market power related to the possession of monopoly-like legacy infrastructure rooted in particular in "last mile" access networks. Incumbent operators initially provided various voice and narrowband (dial-in) Internet services. In the early 2000s incumbents – as well as other operators – started to also provide broadband Internet access based on xDSL and coaxial-cable technologies.

[3] Information available at: https://companiesmarketcap.com/telecommunication/largest-telecommunication-companies-by-market-cap/ and https://groww.in/blog/faang-stocks-performance-over-the-last-decade.

[4] The underlying calculation by WIK-consult (2023) is based on a number of assumptions about how the goals of the digital decade can be achieved at the lowest cost. These include the assumption of a monopoly fibre connection to all currently unconnected households and, similarly, the extension of a single operator's 5G base signal to currently underserved areas. However, it is likely that a large number of households and

partners (European Commission, 2023). The high investment needs in Europe are linked to the massive and continuing growth of internet data traffic, which, on the one hand is due to the current OIR framework, according to which operators must transport with restricted capability to apply traffic management to reduce its impact (an effective "must carry" obligation). For example, average mobile data consumption per capita in the EU is expected to grow from 13 GB/month in 2023 to 76 GB/month in 2030, at a CAGR of 25% (ADL, 2023). Similar growth patterns are identified in a recent industry study (Nokia, 2023). According to Nokia, aggregate global mobile data traffic, is expected to grow from about 100 EB (exabytes) per month at a CAGR of 22% to reach 468 EB (exabytes) per month in 2030. Both industry studies forecast similar growth patterns for global consumer fixed broadband traffic (ADL, 2023; Nokia, 2023). Data growth will be driven mainly by various video streaming services,[5] which account for 60% of the share in 2022 and 70% in 2030. These streaming services are often based on products from a few CPs ("Big Tech"). Sandvine (2022) stated in a report in 2022 that more than half of the global network traffic is attributable to six firms: FAANG and Microsoft.

On the other hand, increased network capabilities will also drive continuous traffic growth. By 2030, 5G will account for half of the world's mobile subscriptions (ADL, 2023; Nokia, 2023) and by 2027, all mobile data traffic growth will come from 5G. The migration to 5G networks implies increasing growth rates in the future. In fact, mobile network traffic grew by 36% between Q1/2022 and Q1/2023 (Ericsson, 2023). Although IP data traffic in both wired and wireless networks has also been subject to significant efficiency gains due to technological innovations such as content delivery networks and advances in compression technologies, consumption-driven growth effects still dominate to a large extent implying overall massive increases of data traffic on ISP networks. The latter is also due to increasing quality of popular services from CPs such as video streaming in combination with increasingly popular HD or UHD plans or 4K resolution (Sandvine, 2023).

Given the high investment requirements, public authorities in some EU and non-EU OECD countries have become increasingly inclined to consider state aid for the deployment of new

consumers will be covered by multiple infrastructures, resulting in much higher total coverage costs. In addition, the WIK calculation does not take into account investment needs beyond the basic coverage extension, such as rearchitecting the network to support unbundling services, costs to upgrade security or costs to expand capacity.

[5] Online video-streaming services cover a range of different usages, including "video on demand", such as films and series (e.g. Netflix, Hulu, Disney+, Apple TV+ or Amazon Prime), "Tube uses" (e.g. YouTube), and social network uses (e.g. Facebook, Instagram or TikTok). Another source for online-video related data growth comes from live streamed video content (e.g. sports rights being acquired by Amazon or DAZN Group).

broadband networks as a necessary policy, in particular, to cover unprofitable, mostly rural areas. Past and current state aid programs in some of the major economies in Europe (and elsewhere) amount to tens of billions of euros (OECD, 2018; Bourreau et al., 2020). The main justification for public funding of broadband networks is related to the positive externalities of general-purpose technologies such as broadband networks, which have been demonstrated in the empirical literature in numerous contributions.[6] Briglauer and Grajek (2023) examine the impact of public subsidy programmes aimed at deploying fibre-based wireline networks. The authors find that these programmes were highly cost-effective due to the induced economic benefits of increased network availability and consumer adoption. The authors, however, also discuss possible efficiency improvements in future funding programmes, in particular requirements for technology neutrality, consideration of mobile broadband solutions and integration of demand-side financing.

In recent years, a new debate on an alternative funding model has emerged under the label of "fair share". As ISPs are forced to constantly expand, upgrade and re-dimension their networks to meet the growing challenge of IP traffic, a controversial debate has emerged on whether Big Tech companies contribute enough to the network costs they generate. This fair share of Big Tech companies in the funding of Europe's telecoms and internet infrastructure officially became part of an EC consultation, launched in February 2023. In October 2023, the EC published a summary report on the consultation. A final decision on any regulatory model underpinning a fair share component is not expected before 2025.[7]

[6] The broadband networks-related literature, the "C" in ICT, has been reviewed by Bertschek et al. (2015) and more recently by Abrardi and Cambini (2019) and Briglauer et al. (2023).

[7] Information available at: https://digital-strategy.ec.europa.eu/en/library/results-exploratory-consultation-future-electronic-communications-sector-and-its-infrastructure. While the current Commission appears to have postponed telcos' calls for Big Tech to pay a fair share, a final decision has been reached in Korea in a three-year legal battle over network usage charges. The legal rulemaking goes back to 2019 when SKB – a South Korean broadband and TV provider, and a unit of incumbent telco SKT – filed a complaint against FAANG company Netflix which is the most popular streaming platform in South Korea and responsible for almost 7% of South Korea's total internet traffic. In 2021, a South Korean court ruled against Netflix´s legal objection arguing that SKB can ask for compensation, and it should be negotiated between two private companies. In September 2023, Netflix, SKBroadband, and SKTelecom announced a strategic partnership after three years of litigation (Strand Consult, 2023). The regulatory debate represents the first case and rulemaking between a domestic ISP and an international CP. A very recent initiative by US government representatives seeks to empower the US regulator FCC to require contributions next to ISPs also from CPs to the "Universal Service Fund". The bipartisan bill aims to reduce

The fair share debate is related to net neutrality regulation in at least two ways. First, Big Tech's sharpest sword is the reference to existing net neutrality rules, which – as they claim – would be threatened by a fair share obligation imposed on the largest CPs. Second, net neutrality rules limit ISPs' ability to monetise their network infrastructure vis-à-vis CPs by imposing binding rules of conduct on ISPs. Both types of regulatory debate are ongoing in the EU, UK, US and elsewhere, and are highly relevant to the quality of modern broadband networks, the infrastructural backbone of the ICT ecosystem.

3 Technological and regulatory developments

In sections 2.1 and 2.2. below we describe the most relevant technological and regulatory developments, respectively, for answering the research question (i). In section 2.3 we outline interim conclusions and implications for 5G network deployments.

3.1 Technological developments

3.1.1 Content Delivery Networks and Private Core Networks

As mentioned in the introductory Section, EU style net neutrality regulation targets only one part of the value chain, i.e. ISPs and their investments in local public access networks which connect backbone networks to the end-users. It therefore excludes from its scope (or, only indirectly impacts) the technologies developed by other market participants such as large CPs (Big Tech), who have invested heavily in their own private networks and strategically distributed services. Typically, they seek to interconnect these private networks with ISP infrastructure to deliver content to the end-user. Note that as the OIR framework only refers to local access (wireline) and radio access (wireless) networks, it is permissible to reach commercial settlement with respect to IP interconnect arrangements (private peering, content delivery networks/caching). However, in practice, it is not feasible for telcos to come to such commercial settlement because OIR effectively also creates “must carry” obligations. Moreover, Big Tech can exercise considerable market power in negotiations derived from the popularity of their services which are considered as “must haves” by large consumer segments. Figure 1 below shows that the current EU-style net neutrality rules focus on one part of the content delivery chain, but do not restrict other parties in the value chain.

The existence of these private networks, including Content Delivery Networks (CDNs), can to some extent introduce service differentiation and bypass the public and regulated Internet (and therefore OIR), as they can manage traffic via these non-regulated private backbones and ensure content is hosted as close to the end-user as possible to guarantee certain quality levels (Stocker

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the financial burden on consumers and rural ISPs while strengthening nationwide connectivity in rural America (information available at: https://telecoms.com/524887/us-moves-to-make-big-tech-contribute-to-broadband-network-costs/).

et al., 2017). CDNs are typically deployed by entities other than ISPs and provide a means for service differentiations that do not violate network neutrality regulations. The majority of Internet traffic is already delivered via third-party CDNs like Akamai or Cloudflare or the distributed serving infrastructures of large CPs like FAANG companies that have strongly expanded their footprints of servers deployed within ISP networks in recent years. By delivering data traffic via own backbone infrastructures, large CPs can considerably reduce their reliance on the public Internet (Stocker et al., 2017, 2020).

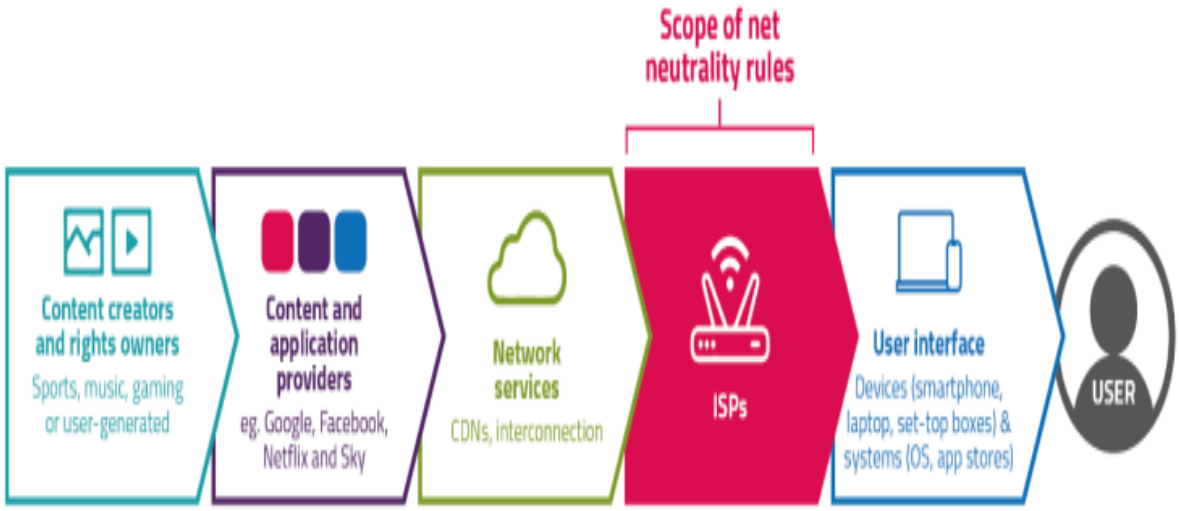

Figure 1: Scope of net neutrality rules in the internet content delivery chain
Source: Ofcom (2023, p. 19)

From a user experience perspective, these and other mechanisms can act as technological substitutes for network management by ISPs, ensuring high quality of experience perceived by the end-user, e.g. lower latency through hosting content at an edge location. From a provider perspective, CDNs and private networks provide an effective way to ensure a certain level of (network-centric) quality of service underlying data transmission, similar to a regime without net neutrality obligations, and thus also provide an effective bypass strategy. The fact that CPs pay a CDN provider or self-supply a CDN to place its content closer to end-users can be seen as a form of paid prioritization even though data traffic is not being prioritized in the network layer (Garrett et al., 2022). In essence, the privatization of network infrastructure by the largest CPs and commercial CDNs has the consequence of an increasing volume of traffic being managed outside the scope of the OIR, and by market actors who are not subject to those rules. Figure 2 below shows the increasing share of global Internet traffic from CDNs, which account for almost 65% of the total global data volume of residential and business IP traffic in 2022.

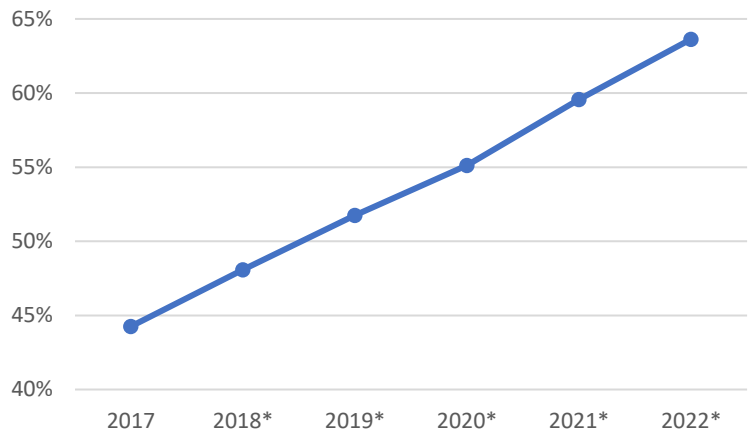

Figure 2: Share of global data traffic delivered via CDNs (forecasts for 2018-2022)
Source: Cisco Visual Networking Index: Forecast and Trends 2017-2022, p. 31; Cisco Visual Networking Index 2018, p. 36

3.1.2 Private and Hybrid Access Networks

In addition to private core networks, there has been an increase in the number of, in particular, enterprise customers, who wish to make use of private access networks to connect their businesses. According to the net neutrality rules, such "non-public" services are also outside the scope of the current rules. However, this concept is typically very narrowly construed, capturing only "classic" private networks for a pre-determined group of end-users only (e.g. a campus mobile private network).

Network slicing offers opportunities to provide a private networking experience in different ways. For example, the concept of "hybrid networks", which offer the ability to create a private networking experience, but without having to build an entirely separate infrastructure, creates regulatory ambiguity. The existing rules and guidance do not provide clarity on these mixed-use networks, leading to potential misinterpretations about their public or non-public status. For example, even when designed for a specific customer (or group of customers), a slice might utilize infrastructure that is shared with the public internet (shared radio access network). Or, the private network slice could exhibit flexibility, bursting into the best-efforts internet, in times of high demand.

3.1.3 Differentiation Based Use Cases and Network as a Service

The emergence of 5G and network slicing capabilities allows for a far more symbiotic relationship between content and connectivity. This will be necessary in the future, as new use cases designed to be supported by these next generation networks are anticipated to have stringent demands with regard to reliable and (ultra) low latency connectivity and local computing via mobile edge computing. Notably, the delivery of such service is expected to require purpose-specific network slices – customized and application-driven virtual networks that can flexibly scale and adapt to

meet the heterogeneous and dynamically changing requirements of an evolving set of different applications. Furthermore, network operators are seeking to offer CPs, who are best placed to determine the demands of their content, service or application, the ability to dynamically select the quality parameters applied to their content, through so-called "quality on demand" Application Programming Interfaces (APIs). This would be a revolution in the way network resources are offered to end-users, and facilitate a more effective and efficient use of network resource.[8]

However, there are potential conflicts between these anticipated 5G-based use cases and associated business models and strict network neutrality regulations, for example how to demonstrate compliance with each application making use of quality on demand APIs with the stringent requirements of the specialised services regime. Potential conflicts between anticipated 5G-based business models and strict network neutrality regulations have been discussed by several scholars from a regulatory and technological perspective in recent years (e.g., Koenig and Veidt, 2023; Yoo, 2023; Yoo and Lambert, 2019; Frias and Martinez, 2017).

3.2 Regulatory developments

3.2.1 EU – BEREC Implementation Guidelines 2016/2020/2022

In contrast to the US, the EU, has continuously maintained its net neutrality regime since 2015 and published net neutrality implementation guidelines first in 2016 (BEREC, 2016). The second version of its (non-binding) net neutrality implementation guidelines were published in 2020 (BEREC, 2020).

Subsequent to this, in September 2021, in a series of interlinking judgements, the European Court (CJEU C-5.20; 34.20; 854.19) prohibited most forms of zero-rating, the practice of allowing end-users to access certain applications or categories of application without this being deducted from their data allowance. With zero-rating, mobile phone providers were able to differentiate themselves from competitors and successfully implement a strategy of product differentiation in which they gained new customers with the help of offers from CPs. This product differentiation could generally be applied to tariffs in different price and consumer segments. As zero-rating constitutes a form of price discrimination it is, however, embedded in the wider net neutrality debate. Consequently, in June 2022, BEREC issued revised guidance on the implementation of the OIR (BEREC, 2022). In this revised guidance, BEREC shifted from an approach of permitting

[8] Many of these product innovations are still in the test phase, partly due to the still limited 5G standalone coverage, but also due to ISPs' concerns over compliance with OIR. For publicly showcased examples see website information of companies, e.g., "Operators are opening up 5G networks to application developers to drive innovation" (ericsson.com) or "Vodafone supports new driverless car-hailing service" (vodafone.com).

popular commercial zero-rating offers provided certain conditions were met, to a broad prohibition on all non-application-agnostic zero-rating offers. This included not just the commercial offers that were the target of the ECJ judgements, but also other forms of zero-rating for public good purposes, such as the zero-rating of consumer support apps, or of critical resources such as health and educational resources (as was common during the Covid-19 pandemic).

The ECJ decision overturned many years of established practice and required mobile operators across Europe to undertake significant and costly programs to migrate customers off zero-rating-based tariffs and to shut these down. Outside the EU, zero-rating is either explicitly allowed, assessed on a case-by-case basis, allowed under certain conditions, subject to unclear ex ante rules or prohibited as well (Garrett et al., 2022). The very restrictive interpretation and application of the rules by the ECJ and consequent revisions to the BEREC guidance, which allowed for no exceptions even for public good zero-rating, are indicative of the strict approach taken by the courts and regulators to the current EU net neutrality regulation.

Furthermore, and in relation to currently deployed 5G technologies, BEREC maintains its position that whilst the net neutrality rules do not per se prohibit 5G network slicing and supported use cases, each innovation must be looked at on a case-by-case basis by the national regulatory authorities.[9] This position encourages an approach of "innovation by permission" only, which again may have a freezing effect on the development of new use cases.

3.2.2 UK – Ofcom Statement on Net Neutrality Review 2023

In October 2023, after a review lasting nearly 3 years, Ofcom (2023) issued revised guidelines on net neutrality compliance, providing a more flexible and permissive approach to network management and service development in the UK.

In particular, the revised guidance (i) clarifies that there is no need to seek prior approval from Ofcom for new services; (ii) provides more flexibility to operators to manage their networks, by providing clearer rules on traffic management. In particular, it allows operators to take action against heavy users where their exceptional usage levels are contributing to congestion on the network to the detriment of other end-users; (iii) sets out further guidance to operators on how they may offer differentiated tiers of internet access services (including how to apply traffic management to facilitate their delivery); and (iv) sets out a more permissive approach to the development of differentiation based specialised services, giving operators more flexibility in how to design such services and demonstrate compliance. Regarding (v) zero-rating, Ofcom´s

[9] Information available at: https://www.berec.europa.eu/en/open-internet/5g.

statement clarifies that the regulator will generally allow these offers, while setting out the limited circumstances where the regulator has some concerns.

Similar to BEREC, Ofcom only has the authority to provide interpretative guidance and set out its enforcement priorities and cannot amend the underlying net neutrality law in the UK. However, it highlighted in its review that aspects of the underlying rules have restricted the development of services and the management of networks that could be beneficial to end-users, due either to ambiguities in the rules, or prohibitions on certain activities. Whilst they stop short of calling for legislative reform, given this is not within Ofcom's remit, they highlight that an alternative approach by the government, and shifting from the current prescriptive rule-based system to a principles-based approach, may be beneficial, particularly given the ever-evolving nature of digital markets. Compared to the EU's strict net neutrality rules, Ofcom's recent statement can be interpreted as a first deregulatory step towards a regime with no or only soft net neutrality rules.

3.2.3 US – FCC Fact Sheet 2023

In October 2023, after securing the nomination of the third democratic FCC Commissioner, the FCC have issued a "Notice of Proposed Rule Making" (FCC, 2023), setting out its proposals to re-introduce open internet regulations to ISPs - broadband internet access service (BIAS) providers in US jargon. This would be achieved by re-classifying BIAS as "Telecommunications Services" under Title II of the "US Communications Act", which provides the FCC with greater regulatory authority and oversight, including the ability to re-introduce open internet rules.

The FCC has sought to justify its intervention on the basis that BIAS are essential to society, and there is therefore a range of policy objectives that would underpin the need for the FCC to regulate them more stringently. In particular, they cite the need to maintain the openness of the internet and to protect free speech as the basis to reclassify BIAS. At the same time, the FCC downgrades the old innovation protections argument for net neutrality.

If successful in their reclassification, the FCC proposes to, essentially, reinstate the measures included in the 2015 Open Internet Order, which was overturned in 2017 during the Trump administration. Similar to current EU net neutrality regulations, these measures include: (i) no blocking or throttling of lawful content, or of the use by consumers of non-harmful devices attached to the network; (ii) no paid prioritization (creation of separate "fast lanes") for any third-party or affiliated content; and (iii) creation of a "general conduct standard", banning any unreasonable interference with end users' ability to use BIAS to access services or content of their choice or to use devices of their choice, and with edge providers' ability to make lawful content, applications, services, or devices available to end users, which would be assessed on a case-by-case basis.

The FCC has indicated that any zero-rating practices would be assessed under this general conduct standard, although they have sought comment on whether they should provide further specific guidance on practices that would, or would not, conflict with the revised rules (including zero-rating and sponsored data practices).

The US proposals would, as in 2015, carve out enterprise services from the scope of BIAS, and are seeking comment on how to classify different core and interconnect services. The final FCC Order is expected to be published during Q2 2024 after a consultation period but will likely be subject to legal challenges.

3.3 Interim conclusions

Technological developments such as CDNs, private core networks or private and hybrid access networks have not only significantly reduced the actual scope of the net neutrality regime and thus its potential effectiveness, but also represent a market-driven bypass strategy. In addition, the emergence of 5G and beyond mobile broadband access networks highlights the future role of applications and use cases that differ significantly in their network requirements (in stark contrast to the best-effort requirements at the beginning of the net neutrality debate 20 years ago). The notion that the growing diversity of demand will require more diverse approaches is challenging the fundamental net neutrality concept of treating all internet traffic equally (Yoo, 2023).

Regulatory developments show that net neutrality policies (including zero-rating rules) vary widely internationally. This creates market distortions and competitive disadvantages for ISPs operating in comparatively strict regimes such as the EU. There may also be practical difficulties, as internet traffic may pass through different countries with different net neutrality rules. But even within countries, the high complexity of net neutrality rules, together with compliance issues related to grey areas around the distinction between unregulated private and regulated public networks and the concepts of reasonable traffic management and specialised services create regulatory ambiguities. Yoo and Lambert (2019) conclude that network slicing seems to align more seamlessly with the concept of specialized services rather than falling under the category of network management, as it seems to be oriented towards applications rather than the network itself. However, the actual interpretation is only determined in official decision-making cases. Case-by-case decisions not only create regulatory uncertainty but also lengthen time-to-market considering the total time required for enforcement decisions and any subsequent legal challenges (Yoo, 2023). This creates considerable market uncertainty that ultimately reduces investment incentives. BEREC's non-binding interpretative guidance adds to uncertainty. Regulatory ambiguity and market uncertainty can also lead to inefficient bypass strategies (Vogelsang, 2018).

Ultimately, EU-style net neutrality regulation faces a dilemma: Either offering very broad exemptions based on reasonable traffic management or specialized services are granted for new technologies such as 5G in particular, making net neutrality regulation even more ineffective, or the above exemptions are granted in a very restrictive manner and based on lengthy case-by-case decisions, which would massively inhibit investment and innovation activity, especially in light of the ongoing 5G rollout or upcoming technologies such as 6G. The EU's approach is of particular concern to ISPs who might otherwise be more inclined to develop and deploy innovative services but find themselves in a grey zone of compliance and subject to high uncertainty.

4 Literature review

While economists have been rather late in approaching the topic of net neutrality regulation, a substantial body of theoretical literature has emerged meanwhile. As this literature has already been synthesized in various surveys, in Section 2.1 we will only briefly outline the main approaches and key findings from economic theory models. In contrast, the empirical literature on the subject remains remarkably limited, and we will provide a comprehensive overview of it in tabular form in Section 2.2. Finally, section 2.3 provides interim conclusions where we briefly summarize our main findings from our balanced reading of the available literature.

4.1 Main results from the theoretical literature

Hildebrandt & Wiewiorra (2023), Jamison (2018), Easley et al. (2018), Greenstein et al. (2016), Krämer et al. (2013), Faulhaber (2011) and finally Schuett (2010) provide comprehensive reviews of the numerous theoretical literature contributions. Most of the theoretical economic literature addresses the impact of network neutrality regulations on market outcomes, mainly through the application of game-theoretic analysis in the context of a two-sided market framework. In this theoretical framework, ISPs facilitate access for end-users while at the same time providing access to CPs. These CPs rely on ISPs to transmit content-related data to end-users, effectively making ISPs the connecting platform between CPs and end-users. Net neutrality rules are conceptualised as comprehensive ex ante interventions that either enforce traffic rules requiring equal treatment of all traffic by ISPs or prohibit ISPs from charging CPs for access to content and applications. Theoretical models contrast a scenario where net neutrality is enforced with no price and quality differentiation with a scenario where ISPs can deviate by offering premium service classes for prioritised traffic delivery, typically with access charges. In the latter scenario, ISPs are free to negotiate contracts with CPs. While these models analyse various trade-offs, including social welfare, network investment, content innovation, consumer prices, profits and demand, the results vary depending on the parameters and underlying assumptions (Briglauer et al., 2022). However, in terms of ISP profits and investment incentives, most models

show that without net neutrality regulation ISP profits increase and so do incentives to invest in new infrastructure (Easley et al., 2018).

Firat and Xingyi (2019) analysed the use of zero rating as a purely discriminatory practice implemented by monopolistic ISPs. The authors found that it can lead to an increase in welfare if it leads to an expansion of network capacity by the monopolistic ISP. In addition, four papers explicitly consider the economic effects of sponsored data plans in the context of a two-sided market model: Jullien and Sand-Zantman (2016), Gautier and Somogyi (2020), Jeitschko et al. (2018), and Hoernig and Monteiro (2020). These papers identify circumstances in which an ISP would make greater profits under a sponsored data regime,[10] and therefore has an incentive to implement it if it is allowed. All the aforementioned papers show that the welfare effects of sponsored data models are ambiguous; depending on the parameters, sponsored data can increase or decrease overall welfare.

4.2 Main results from the empirical literature

In contrast to the theoretical literature, empirical contributions are few. To the best of our knowledge, Table 1 provides a structured overview of all currently available empirical contributions in chronological order. The tabular presentation of the effects of net neutrality regulation focuses on the following effects of main economic policy variables of interest: (i) Investment (INVEST): Positive or negative incentives for ISPs to invest? (ii) Innovation (INNOV): Positive or negative incentives for innovation on the part of CPs? (iii) Demand (USE): Positive or negative effects on demand in terms of demand for services by consumers? (iv) Welfare effects (WF): Positive or negative effects on total welfare? [11]

Several empirical papers (4 out of 9) have examined the impact of net neutrality regulations on network investment by (wireline) ISPs. This literature is mostly based on US data and monetary measures of investment (Ford, 2018; Ford et al., 2010; Hazlett and Wright, 2017). Only Briglauer et al. (2022) used OECD panel data and were the first to measure investment activity in physical units, in terms of newly installed fibre-based broadband connections in local access networks. Lee and Kim (2014), Layton (2017), Bauner and Espin (2022) and Túdon (2022) examine the impact on other outcome variables such as content innovation, content usage or social welfare. Only

[10] In zero-rating tariffs, it is also possible that a CP pays for the end-user's data consumption when using a certain service or application. This practice is called "sponsored data".

[11] To the best of our knowledge there is no empirical evidence so far regarding the impact on other relevant economic policy variables, such as the profitability of ISPs or consumer prices for broadband access services.

Layton (2017) and Bauner and Espin (2023) use mobile broadband data to examine impacts on content innovation (mobile apps) and consumer demand (app usage), respectively.

In summary, reliable empirical evidence on the different channels of net neutrality regulation is very limited, even more so when focusing on empirical studies with a reliable strategy to identify causal effects that can truly inform policymakers. However, all previous empirical contributions using different data and measures of network investment have found a negative impact of net neutrality regulation on the investment activities of (wireline) ISPs, which is also in line with most predictions in the theoretical contributions. This result is strengthened by the fact that the available studies use different data sets, with temporal and spatial differences, as well as different measures of investment activity. Moreover, this result is also supported by the related empirical broadband literature, which finds a negative effect of different types of sector-specific access regulation on network operators' investment activity (Briglauer et al., 2018; Grajek & Röller, 2011). Three studies (Nurski, 2012; Lee and Kim, 2014; Túdon, 2022) use structural equation or simulation-based estimation models and find that net neutrality regulations ultimately lead to negative welfare effects. Finally, one study (Layton, 2107) finds negative effects on mobile app innovation and one study (Bauner and Espin, 2023) finds insignificant effects on app usage.

Finally, to the best of our knowledge, there is only one empirical study that examines the impact of zero-rating which was conducted by the Austrian regulatory authority (RTR, 2019). The authors use data on smartphone tariff characteristics in 15 EU countries for 53 mobile operators over the years 2015-2018. Controlling for systematic differences between operators (operator fixed effects) and allowing for a flexible time trend (time fixed effects), the authors find no evidence that zero-rating reduces included data volumes or increases prices per GB or monthly prices across all countries and time periods. Rather, some of their results suggest that, ceteris paribus, zero-rating is associated with higher data caps and lower prices per GB. However, the authors admit that their results are not robust in all specifications.

4.3 Interim conclusions

While there is no conclusive evidence related to content innovation and usage, or the economic impact of zero-rating practices, the available evidence points to the negative investment effects of net neutrality regulations, which also seem to lead to negative welfare effects in the long term. Conversely, there is so far not a single piece of empirical evidence supporting the positive effects claimed by net neutrality proponents.

Table 1: Empirical Contributions on the Impact of Net Neutrality Regulations

Author(s)	Methodology	Data	Time	INVEST	INNOV	USE	WF
Ford et al. (2010)	Event studies, OLS regression	Firm-level data Stock returns of US ISPs	Several dates in May 2010 (4, 5, 6, 7, 8)	**-**	**n.c.**	**n.c.**	**n.c.**
Nurski (2012)	SEM	UK household-level data on ISP and content choices; market-level data on ISP availability	2009	**n.c.**	**n.c.**	**n.c.**	**-**
Lee and Kim (2014)*)	Simulation-based demand estimation*)	Micro-level data Survey of South Korean internet users	2012	**n.c.**	**n.c.**	**n.c.**	**-**
Hazlett and Wright (2017)	Descriptive analysis and OLS regression	Industry-level data US broadband network investments	1996–2014	**-**	**n.c.**	**n.c.**	**n.c.**
Layton (2017)	Descriptive analysis and OLS regression	Micro-level data Mobile App downloads per day in Denmark and in the Netherlands	Selected days in 2011, 2012, 2016	**n.c.**	**-**	**n.c.**	**n.c.**
Ford (2018)	DiD regression	Industry-level data Investment in the US telecom sector and selected control industries	1980–2016	**-**	**n.c.**	**n.c.**	**n.c.**
Tudón (2022)	SEM	Stream-level data on State of Amazon's Twitch.tv measured every 10 minutes for 90 days	Jan 6 2014 – Apr 6 2014	**n.c.**	**n.c.**	**n.c.**	**-**
Briglauer et al. (2022)	FE, IV estimation	OECD country-level data Real investment in fiber-based broadband lines	2002–2021	**-**	**n.c.**	**n.c.**	**n.c.**
Bauner and Espin (2023)	FE, IV estimation	Firm and market-level data Throughput levels for US mobile ISPs US market-level data	215.000 throughput tests conducted in 2018	**n.c.**	**n.c.**	**~**	**n.c.**

Notes: Policy variables: (i) network investments (INVEST); (ii) content innovation (INNOV); (iii) consumer subscriptions and content usage (USE); (iv) welfare (WF) incl. consumer surplus; positive, negative and insignificant effects of net neutrality regulations on these outcome variables are presented as "+", "-", and "~", respectively. "n.c." (no conclusions) means that the impact on the respective outcome variable is not examined by the respective authors. OLS: ordinary least squares; FE: Fixed-effects. DiD: Difference-in-difference; IV: Instrumental variables; SEM: Structural estimation modelling. *) Simulation model #6 examines the impact of net neutrality regulations.
Source: Own presentation based on Briglauer et al. (2022).

5 Mobile broadband market developments in the EU and in the US

This section presents key and policy-relevant developments in the mobile communications sector in the period 2007-2021 in descriptive form. The underlying analysis period covers the most important decisions and changes in net neutrality policy in the group of highly developed countries. In addition to the demand-side subscription figures, supply-side figures on investments (5G coverage and CAPEX) and profits (EBITDA) of mobile network operators are also presented over time for different groups of countries with opposing net neutrality regulations. In particular, our international comparison includes (i) a group of European countries[12] representing a jurisdiction with strict regulatory measures formally implemented in 2015, (ii) Japan and Korea (JPN+KOR) as the first countries to implement net neutrality regulations, which are, however, considered as comparatively moderate market interventions, (iii) Australia and New Zealand (AUS+NZL) as countries that had never implemented net neutrality regulations, and finally (iv) the United States (US) with a comparatively strict net neutrality regime during 2015-2017, and a complete withdrawal of these rules in 2017-2021 (Garrett et al., 2022). Main policy changes (year of rulemaking) in the EU (2015) and US (2017) are indicated with vertical lines in Figures 1 to 4.

From Figure 1 we can see that mobile broadband subscriptions (incl. both postpaid and pre-paid subscriptions) seem to follow a constant growth pattern in all groups of countries with a high path dependency for the selected groups of countries. Only for the group of European countries can a slight decline be observed after 2015. Figure 2 shows the state of 5G deployment split by world region and technology. Low, medium and high frequency bands will be used for 5G deployment. Each band has its own characteristics, benefits and limitations. The mid-band offers a technological balance between speed and coverage. Internationally, there is heterogeneity not only in the use of 5G mid-band technology ("5G mid-band"), but also in the total 5G deployment ("5G total") by the end of 2022. In terms of 5G total Europe appears to substantially lag behind China and the US by around 32 and 37 percentage points, respectively.

From Figures 3 and 4 it can be concluded that the investment and profit patterns of mobile ISPs are subject to much greater variation than aggregate subscription data, both within the analysis period and between groups of countries. While the US shows some upward trends in investment and profits, EU countries show downward or moderate trends in investment and profits.

[12] Our aggregate data for the group of European countries include the following states: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom. Please note that non-EU member state Norway adopted similar net neutrality regulations, and United Kingdom did not deviate from EU net neutrality rules until the end of our observation period.

5.1 Interim conclusions

Obviously, the reported market variables are driven simultaneously by a variety of different demand and supply side determinants. For example, broadband investment is also determined by public funding, which is another important policy variable that has a direct impact on network coverage. In addition, we observed wide variations in broadband funding policies internationally, with comparatively high per capita funding in countries such as Australia, New Zealand or the US (OECD, 2018). Even if the analytical value of descriptive time series comparisons is limited, there is no obvious negative evidence for the US deregulation policy in 2017 and, conversely, no obvious positive evidence for the introduction of the EU regulatory regime in 2015.

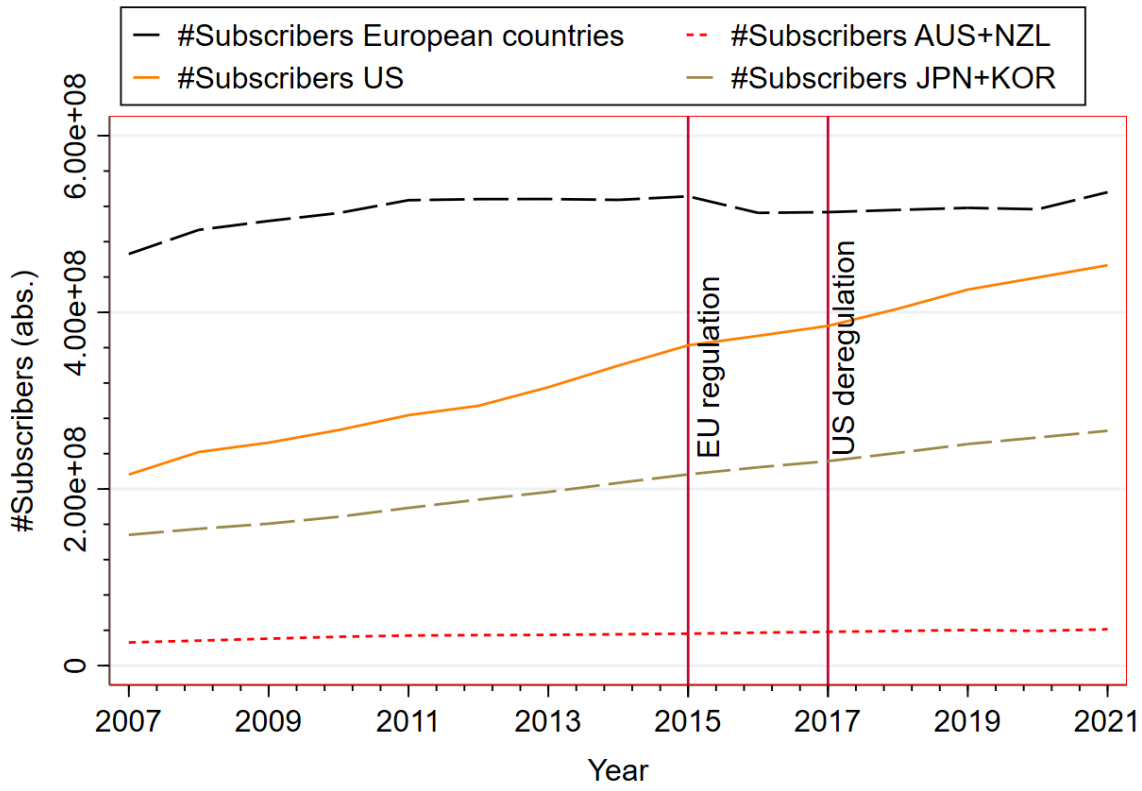

Figure 3: Number of mobile broadband subscribers (post- and prepaid) by group of countries
Source: Global Wireless Matrix - BofA Global Research

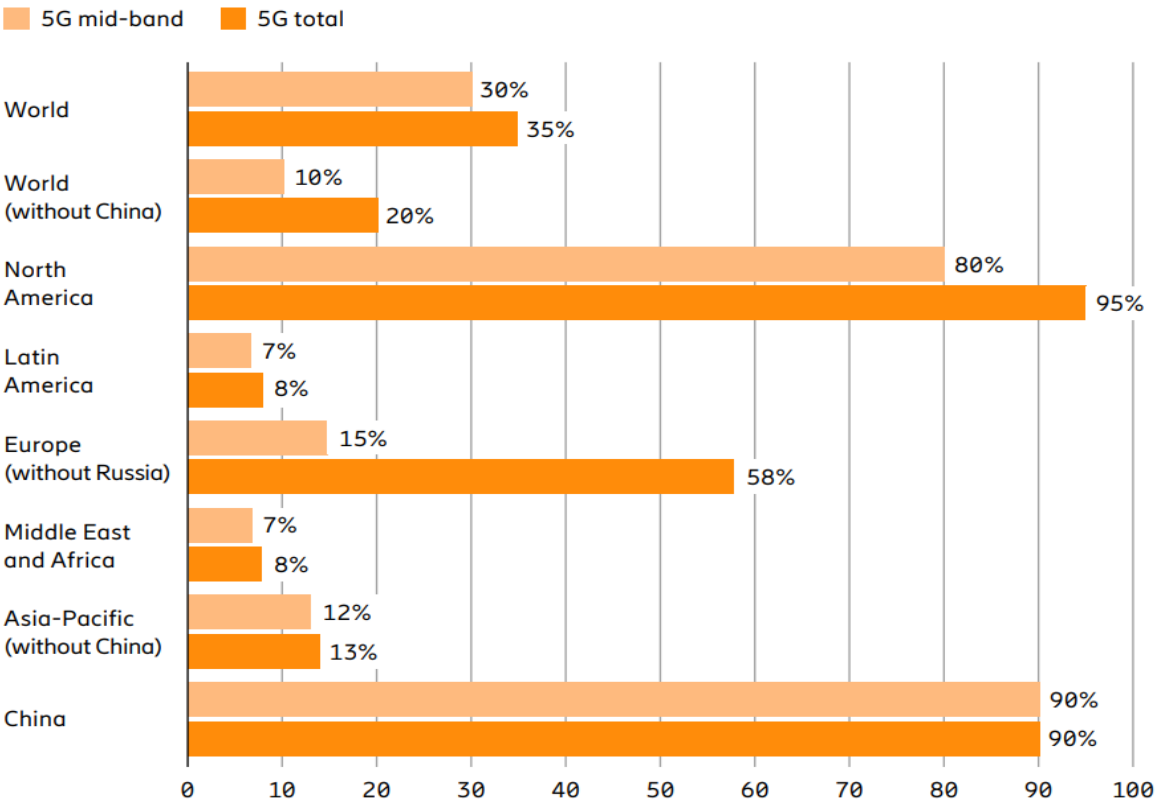

Figure 4: Percent of population with 5G coverage split by technology and region (end of 2022)
Source: Ericsson (2023, p. 21)

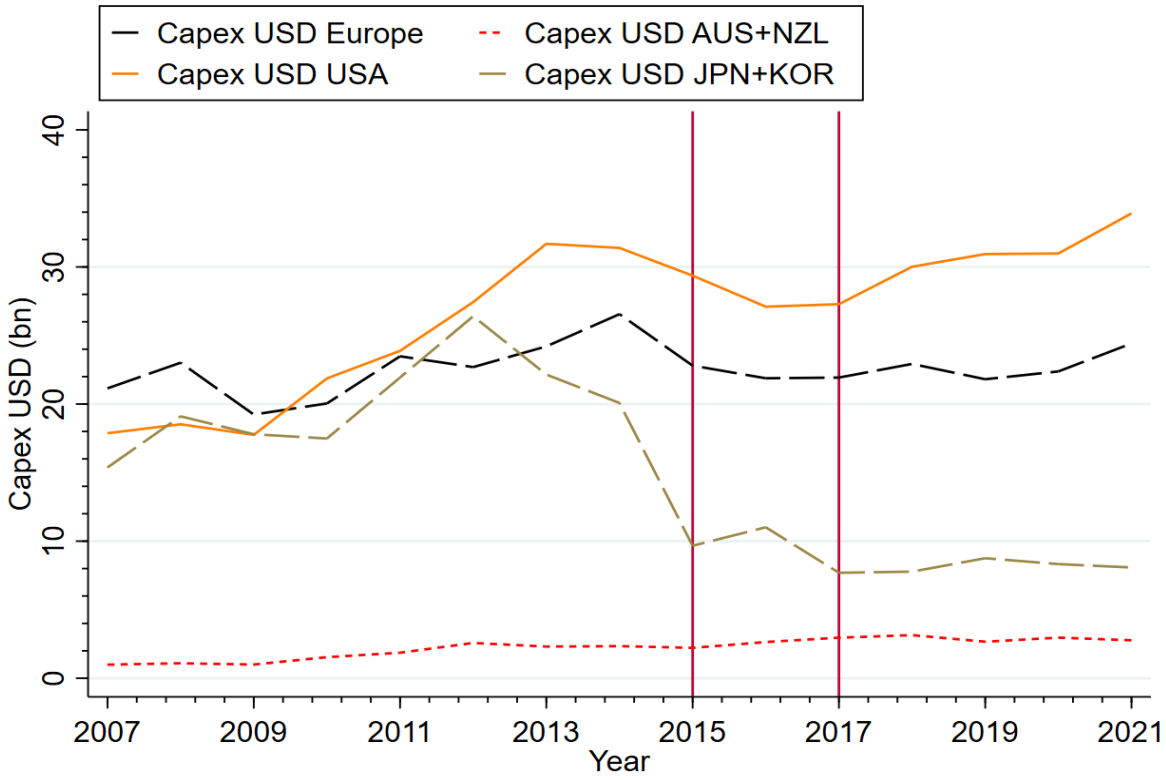

Figure 5: CAPEX in USD (bn) by group of countries
Source: Global Wireless Matrix - BofA Global Research

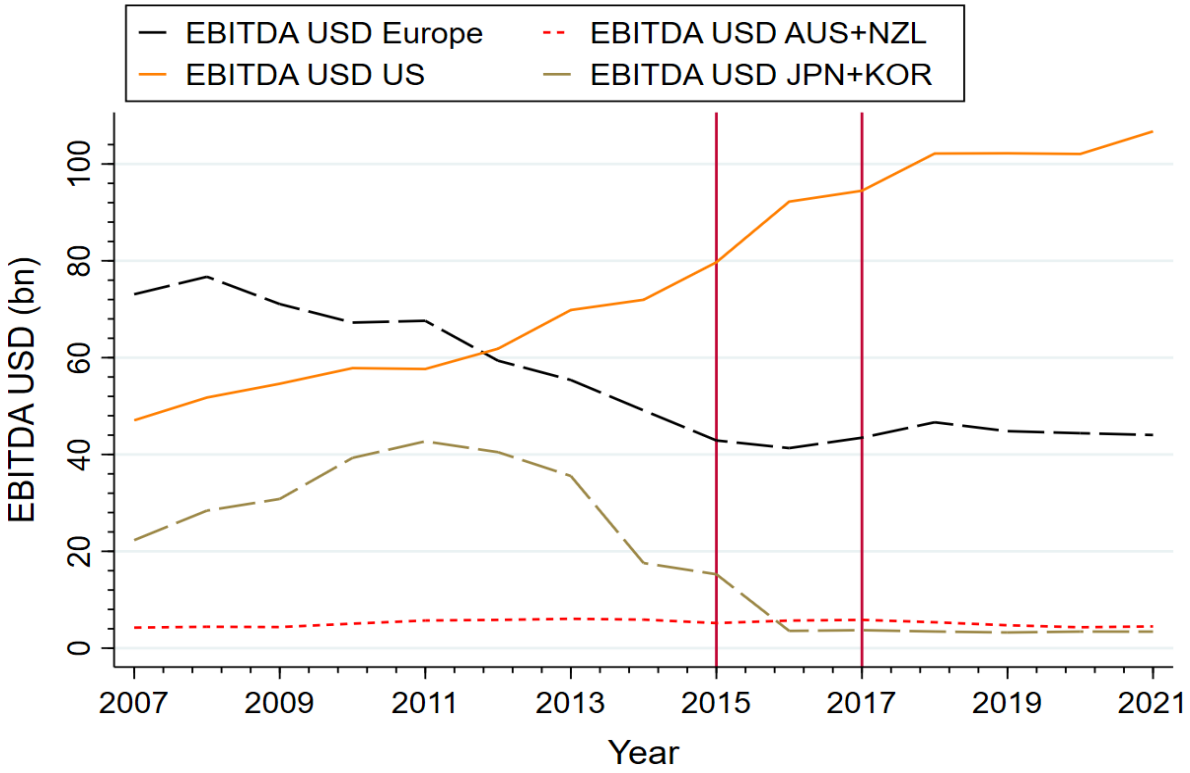

Figure 6: EBITDA in USD (bn) by group of countries
Source: Global Wireless Matrix - BofA Global Research

6 Final conclusions and policy recommendations

Our analysis and literature review showed that current EU-style net neutrality regulation is likely to have negative effects on investment and, in the long run, on welfare. Moreover, as historical developments in the EU and the US have shown, net neutrality decisions lead to high costs in terms of implementation, monitoring and enforcement of net neutrality rules, as well as potential market distortions, including market uncertainty due to compliance grey areas and lengthy case-by-case decisions. Taken together with findings from the empirical literature and descriptive evidence on relevant mobile market policy variables, this leads to the conclusion that net neutrality regulation is likely to be inefficient, implying negative welfare effects, even more so when considering the overall regulatory costs. In any case, there is no empirical or anecdotal evidence from trends in key mobile broadband indicators that would support the arguments of proponents of net neutrality policy. This is an important finding as the burden of proof should be on the side of strong interventionist ex ante regulation.

Important technological developments, such as the ongoing roll-out of 5G networks, different types of private networks and CDNs, imply that the actual scope of net neutrality rules, and therefore their effectiveness, is constantly narrowing, which further worsens the cost-benefit calculation of this regulatory intervention. In addition, market distortions arise because of wide policy differences between countries and jurisdictions, and because regulatory ambiguities embedded in net neutrality rules lead to bypass strategies. Where net neutrality rules are ineffective, they are also likely to create further inefficiencies through the cost and allocation inefficiencies caused by bypass (Vogelsang, 2018).

In terms of both efficiency and effectiveness, it follows that providers of broadband internet access services (ISPs/BIAS) should be given more options for pricing and quality design, subject to established ex-post competition law, combined with the possibility of sanctions in cases of abusive discrimination (Jamison, 2018; Vogelsang, 2018) as well as existing sectoral transparency and end-user protections. Alternatively, regulators could consider a principles-based framework, that sets out guidance on what operators should do to ensure an open and non-discriminatory network experience, but offers more flexibility with only limited scope of ex ante obligations and hence also less compliance grey zones and regulatory uncertainty. A step in the right direction, albeit a small and cautious one, was taken by the recent decision of the UK regulator Ofcom. In almost the same period, and in contrast to Ofcom´s statement and our analysis, the US regulator FCC decided to start a process to re-impose strict net neutrality rules.

Strict EU-style net neutrality rules not only run counter to the objectives underlying the fair share debate launched by ISPs, but also to the EC's intention under its Digital Markets Act (European Commission, 2022) to limit the market power of gatekeepers or core platform services (Big Tech),

such as online search engines, app stores, messenger services in popular online services. European ISPs are under considerable market pressure, as recently acknowledged by EU Commissioner Thierry Breton in a linked-in post:[13] "Low returns on investment, long payback periods and market uncertainties, in turn, reduce the attractiveness of the telecoms sector for investors who want to put their money in building the networks of the future, rather than squeezing legacy copper networks. In the long run this can weaken the sector and expose it to hostile take-overs, despite the critical nature of its assets." Commissioner Breton furthermore argues that a major reason for this market situation is overregulation in the EU: "Too many regulatory barriers to a true telecoms Single Market still exist, on spectrum acquisition, consolidation, legacy networks, security, and so on." While the fair share debate has been apparently postponed by the European Commission, Breton admits that "finding a financing model for the huge investments needed is an important issue that we will need to deal with." The Commission´s solution is to create another "bold, future-oriented, game-changing" regulation with the acronym DNA, "Digital Networks Act", unlikely to be available before 2025 and subject to evaluation by a new Commission. This will be preceded by a white paper within this Commission mandate (likely by mid-2024), setting the parameters for the DNA.

A much simpler and more timely option would be to remove or significantly soften obvious investment-hindering over-regulation, such as net neutrality rules. This option, which could be signposted in the upcoming white paper on the future regulation of the sector, would have much lower institutional costs and might even be more effective than another act. As suggested by commissioner Breton, we also recommend that the EU explores complementary models that would support the public funding of network infrastructure. For example, in the US there is now discussion of expanding the scope of their Universal Service Fund (footnote 6), so that other market actors who benefit from network infrastructure (the largest CPs/Big Tech), would be required to proportionately contribute to the public funding of network expansion. Recognizing the fundamental changes in the ICT ecosystem, this approach should be considered within the EU. This approach is to some extent similar to previous broadband funding in the EU, but instead of funding through general taxation, funding would be proportionate to the economic size of market actors in the ICT industry ecosystem. Given the decades of experience in the EU (and elsewhere) with USO and broadband deployment funding models, this approach also appears feasible in the medium term and justified given the well-documented socio-economic benefits of modern broadband networks in the empirical literature.

[13] Direct citations taken from the linked-in post are available at: https://www.linkedin.com/pulse/digital-networks-act-redefine-dna-our-telecoms-thierry-breton.

In terms of a future research agenda, much more empirical evidence is needed on the impact of net neutrality rules on content innovation, usage or consumer prices, given that the underlying regulation and the current controversial debates and decisions in Europe and the US have been largely driven by ideological views and political economy considerations in a largely economic and evidence-free zone. For example, future research should examine the quasi-natural experiment underlying the US-style net neutrality policy changes that resulted from the general election. Similarly, there is currently little evidence on the impact of net neutrality rules (including zero-rating decisions) on relevant mobile broadband market outcomes.

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References

Abrardi, L., & Cambini, C. (2019). Ultra-fast broadband investment and adoption: A survey. *Telecommunications Policy, 43*(3), 183–198. https://doi.org/10.1016/j.telpol.2019.02.005

ADL – Arthur D Little. (2023). *The Evolution of the Data Growth in Europe*. Report. https://www.adlittle.com/sites/default/files/reports/ADL_Data_growth_Europe_2023.pdf

Bauner, C., & Espin, A. (2023). Do subscribers of mobile networks care about Data Throttling? *Telecommunications Policy, 102665*. https://doi.org/10.1016/j.telpol.2023.102665

BEREC. (2022). *Guidelines on the implementation of the open internet regulation [BoR (22) 81]*. https://www.berec.europa.eu/en/document-categories/berec/regulatory-best-practices/guidelines/berec-guidelines-on-the-implementation-of-the-open-internet-regulation-0

BEREC. (2020). *Guidelines on the Implementation of the Open Internet Regulation, [BoR (20) 112]*. https://berec.europa.eu/eng/document_register/subject_matter/berec/regulatory_best_practices/guidelines/9277-berec-guidelines-on-the-implementation-of-the-open-internet-regulation

BEREC. (2016). *Guidelines on the implementation by national regulators of European net neutrality rules [BoR (16) 127]*. https://berec.europa.eu/eng/document_register/subject_matter/berec/regulatory_best_-practices/guidelines/6160-berec-guidelines-on-the-implementation-by-national-regulators-of-european-net-neutrality-rules

Bertschek, I., Briglauer, W., Hüschelrath, K., Kauf, B., & Niebel, T. (2015). The Economic Impacts of Broadband Internet: A Survey. *Review of Network Economics, 14*(4), 201–227. https://doi.org/10.1515/rne-2016-0032

Bourreau, M., Feasey, R., & Ambre, N. (2020). Assessing Fifteen Years of State Aid for Broadband in the European Union: A Quantitative Analysis. *Telecommunications Policy, 44*(7), 101974. https://doi.org/10.1016/j.telpol.2020.101974

Briglauer, W. (2015). How EU sector-specific regulations and competition affect migration from old to new communications infrastructure: recent evidence from EU27 member states. *Journal of Regulatory Economics, 48*(2), 194–217. DOI: 10.1007/s11149-015-9283-1

Briglauer, W., Cambini. C. & Grajek, M. (2018). Speeding up the internet: regulation and investment in the European fiber optic infrastructure. *International Journal of Industrial Organization, 61*(C), 613–652. DOI: 10.1016/j.ijindorg.2018.01.006

Briglauer, W., Gugler, K., Cambini, C. & Stocker, V. (2022). Net neutrality and high-speed broadband networks: evidence from OECD countries. *European Journal of Law and Economics*. https://doi.org/10.1007/s10657-022-09754-5

Briglauer, W., Krämer, J. & Palan, N. (2023). Socioeconomic benefits of high-speed broadband availability and service adoption: A Survey. *EcoAustria research paper no. 24*. https://ecoaustria.ac.at/high-speed-broadband-survey/

Briglauer, W., & Grajek, M. (2023). Effectiveness and efficiency of state aid for new broadband networks: evidence from OECD member states. *Economics of Innovation and New Technology* (forthcoming). doi: 10.1080/10438599.2023.2222265

Easley, R. F., Guo, H. & Krämer, J. (2018). Research commentary – from net neutrality to data neutrality: a techno-economic framework and research agenda. *Information Systems Research, 29*(2), 253–272. https://doi.org/10.1287/isre.2017.0740

Ericsson (2023). Mobility Report – June 2023. https://www.ericsson.com/49dd9d/assets/local/reports-papers/mobility-report/documents/2023/ericsson-mobility-report-june-2023.pdf

ETNO - European Telecommunications Network Operators' Association (2023). State of Digital Communications 2023. https://etno.eu/library/reports/112-the-state-of-digital-communications-2023.html

European Union. (2015). Regulation (EU) 2015/2120 of the European Parliament and of the Council of 25 November 2015 laying down measures concerning open internet access and amending Directive 2002/22/EC on universal service and users' rights relating to electronic communications networks and services and Regulation (EU) No 531/2012 on roaming on public mobile communications networks within the Union, *Official Journal of the European Union, L 310, 1–18, 26 November, Brussels, Belgium*.

European Commission (2022). Regulation (EU) 2022/1925 of the European Parliament and of the Council of 14 September 2022 on contestable and fair markets in the digital sector and amending Directives (EU) 2019/1937 and (EU) 2020/1828 (*Digital Markets Act*).

European Commission (2023). Report on the state of the Digital Decade 2023, *27 November, Brussels, Belgium.*

Faulhaber, G. R. (2011). Economics of net neutrality: a review. *Communications & Convergence Review, 3*(1), 7–25. https://doi.org/10.1515/rne-2019-0025

Federal Communications Commission. (2015). In the matter of protecting and promoting the open internet, report and order on remand, declaratory ruling, and order, *GN Docket No. 14-28* (*FCC 15–24*), adopted: 26 February, released: 12 March, Washington, D.C.: Federal Communications Commission.

Federal Communications Commission. (2018). In the matter of restoring internet freedom, declaratory ruling, report and order, and order, *WC Docket No. 17-108* (*FCC 17-166*), adopted: 14 December, released: 4 January, Washington, D.C.: Federal Communications Commission.

Federal Communications Commission. (2023). *FCC Fact Sheet - Safeguarding and Securing the Open Internet*. Notice of Proposed Rulemaking – *WC Docket No. 23-320*.

Firat, I. & Xingyi, L. (2019). Multiproduct price discrimination with quantity limits: an application to zero-rating. *Economics Letters, 180*, 41–45. DOI: 10.1016/j.econlet.2019.04.002.

Ford, G. S. (2018). Regulation and investment in the US telecommunications industry. *Applied Economics, 50*(56), 6073–6084. DOI: 10.1080/00036846.2018.1489115.

Ford, G. S., Spiwak, L. J., & Stern, M. L. (2010). The broadband credibility gap. *CommLaw Conspectus, 19*, 75.

Frias, Z., & Martínez, J.P. (2018). 5G networks: Will technology and policy collide? *Telecommunications Policy, 42*(8), 612-621. https://doi.org/10.1016/j.telpol.2017.06.003

Garrett, T., Setenareski, L. E., Peres, L. M., Bona, L. C. E. & Duarte, E. P. (2022). A survey of network neutrality regulations worldwide. *Computer Law & Security Review, 44*, Article 105654. DOI: 10.1016/j.clsr.2022.105654.

Gautier, A. & Somogyi, R. (2020). Prioritization vs zero-rating: discrimination on the internet. *International Journal of Industrial Organization, 73*, Article 102662. https://doi.org/10.1016/j.ijindorg.2020.102662.

Grajek, M. & Röller, L. H. (2012). Regulation and investment in network industries: evidence from European telecoms. *Journal of Law and Economics, 55*, 189–216. http://dx.doi.org/10.1086/661196.

Greenstein, S., Peitz, M. & Valletti, T. (2016). Net neutrality: A fast lane to understanding the trade-offs. *Journal of Economic Perspectives, 30*(2), 127–150. DOI: 10.1257/jep.30.2.127.

Hazlett, T. W. & Wright, J. D. (2017). The effect of regulation on broadband markets: evaluating the empirical evidence in the FCC's 2015 "open internet" order. *Review of Industrial Organization, 50*(4), 487–507. DOI: 10.1007/s11151-016-9556-6.

Hildebrandt, C., & Wiewiorra, L. (2023). The past, present, and future of (net) neutrality: A state of knowledge review and research agenda. *Journal of Information Technology, 0*(0). https://doi.org/10.1177/02683962231170891

Hoernig, S. & Monteiro, F. (2020). Zero-rating and network effects. *Economics Letters, 186*, Article 108813. https://doi.org/10.1016/j.econlet.2019.108813.

Jamison, M. (2018). Net neutrality policies and regulation in the United States. *Review of Network Economics, 17*(3), 151–174. DOI: 10.1515/rne-2018-0041.

Jeitschko, T. D., Kim, S. J. & Yankelevich, A. (2019). Zero-rating and vertical content foreclosure [DICE discussion paper no. 317]. *Düsseldorf Institute for Competition Economics (DICE)*. https://www.dice.hhu.de/fileadmin/redaktion/Fakultaeten/Wirtschaftswissenschaftliche_Fakultaet/DICE/Discussion_Paper/317_Jeitschko_Soo_Yankelevich.pdf.

Jullien, B. & Sand-Zantman, W. (2021). The economics of platforms: a theory guide for competition policy. *Information Economics and Policy, 54*, Article 100880. https://doi.org/10.1016/j.infoecopol.2020.100880.

Koenig, C. & Veidt, A. (2023). Lifting a regulatory millstone around 5G investors' neck – 5G network slicing versus EU-net neutrality? *Telecommunications Policy*, *47*(10), Article 102653. https://doi.org/10.1016/j.telpol.2023.102653.

Krämer, J., & Peitz, M. (2018). A fresh look at zero-rating. *Telecommunications Policy, 42*, 501–513. DOI: 10.1016/j.telpol.2018.06.005.

Krämer, J., Wiewiorra, L. & Weinhardt, C. (2013). Net neutrality: a progress report. *Telecommunications Policy, 37*(9), 794–813. DOI: 10.1016/j.telpol.2012.08.005.

Layton, R. (2017). Which open internet framework is best for mobile app innovation? An empirical inquiry of net neutrality rules around the world [Doctoral thesis, Aalborg Universitet]. *Aalborg Universitetsforlag*. https://doi.org/10.5278/vbn.phd.engsci.00181.

Lee, D. & Kim, Y. H. (2014). Empirical evidence of network neutrality: the incentives for discrimination. *Information Economics and Policy, 29*, 1–9. DOI: 10.1016/j.infoecopol.2014.07.001.

Lorenzon, E. (2022). Zero-rating, content quality, and network capacity. *Information Economics and Policy, 58*, Article 100965. DOI: 10.1016/j.infoecopol.2022.100965.

Nokia (2023). *Global Network Traffic 2030 Report*. https://onestore.nokia.com/asset/213660

Nurski, L. (2012). Net Neutrality, Foreclosure and the Fast Lane: An empirical study of the UK. https://www.semanticscholar.org/paper/Net-Neutrality%2C-Foreclosure-and-the-Fast-Lane%3A

OECD (2018). Bridging the Rural Digital Divide. *OECD Digital Economy Papers No. 265, Paris*.

Ofcom (2023). Net Neutrality Review – Statement. https://www.ofcom.org.uk/__data/assets/-pdf_file/0017/270260/Statement-Net-Neutrality-Review.pdf

RTR (2019). Zero-Rating in the EU: An empirical investigation into the effects on data caps and prices in 15 countries. Vienna. https://www.rtr.at/TKP/aktuelles/publikationen/-publikationen/ZeroRatingEU2019.de.html.

Sandvine (2022). The Mobile Internet Phenomena Report. https://www.sandvine.com/phenomena

Sandvine (2023). Global Internet Phenomena Report. https://www.sandvine.com/global-internet-phenomena-report-2023

Schuett, F. (2010). Network neutrality: a survey of the economic literature. *Review of Network Economics, 9*(2), 1–15. DOI: 10.2202/1446-9022.1224.

Stocker, V., Smaragdakis, G., Lehr, W.H. & Bauer, S. (2017). The Growing Complexity of Content Delivery Networks: Challenges and Implications for the Internet Ecosystem. *Telecommunications Policy, 41*(10), 1003-1016.

Stocker, V. (2020). Innovative Capacity Allocations for All-IP Networks: A Network Economic Analysis of Evolution and Competition in the Internet Ecosystem. *Nomos Baden-Baden*.

Strand Consult (2023). Netflix v. SK Broadband. The David and Goliath Battle for Broadband Fair Cost Recovery in South Korea. https://strandconsult.dk/netflix-v-sk-broadband-the-david-and-goliath-battle-or-broadband-fair-cost-recovery-in-south-korea/

Tudón, J. (2022). Prioritization vs. congestion on platforms: evidence from Amazon's Twitch.tv. *RAND Journal of Economics, RAND Corporation, 53*(2), 328-355.

Vogelsang, Ingo. (2018). Net Neutrality Regulation: Much Ado about Nothing? *Review of Network Economics, 17*(3), 225-243. https://doi.org/10.1515/rne-2018-0051

WIK-Consult (2023). Investment and funding needs for the Digital Decade connectivity targets. Study prepared for the European Commission, *Brussels*.

Wu, T. (2002). A proposal for network neutrality. http://www.timwu.org/OriginalNNProposal.pdf

Wu, T. (2003). Network neutrality, broadband discrimination. *Journal on Telecommunication and High Technology Law, 2*, 141–179.

Yoo, C. S. & Lambert, J. (2019). 5G and net neutrality. In G. Knieps & V. Stocker (Eds.), *The future of the internet: innovation, integration and sustainability* (pp. 221–245). *Nomos*.

Yoo, C. (2023). Network slicing and net neutrality. *Telecommunications Policy*, 102619. https://doi.org/10.1016/j.telpol.2023.102619.