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. In terms of efficiency and effectiveness, the "first best" policy recommendation would be to remove obvious over-regulation that impedes investment, such as net neutrality rules. The "second best" policy recommendation in terms of actual political feasibility 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, and in view of proven externalities, policy-makers should also explore complementary funding models.

1 Introduction

As the debate over net neutrality on the Internet is changing as it enters its third decade.[1] Proponents of net neutrality have attempted to prevent ISPs from exploiting their "gatekeeper" position in local access markets to discriminate against unaffiliated content and application service providers by establishing rules requiring last-mile ISPs to carry all Internet traffic without discrimination, blocking, throttling, or prioritization. Moreover, some versions of net neutrality also impose a zero-price rule prohibits an ISP from charging a content provider (CP) a "termination fee" to send data in wireline or wireless "last-mile" access networks to consumers.

In the United States, net neutrality has followed a tortuous and partisan path. During the administration of George W. Bush, Federal Communications Commission (FCC) Chairman Michael Powell (2004) gave a landmark speech endorsing the basic tenets of net neutrality, and the agency subsequently enshrined these principles in a nonbinding Policy Statement (FCC, 2005). Following the election of President Barack Obama, the FCC issued orders turning these policy missives into binding law (FCC, 2010, 2015).[2] Change in the political party controlling the White House led to the repeal (FCC, 2018) and reinstatement of these rules (FCC, 2024). The impending return of Donald Trump to the White House, his designation of a net neutrality critic as FCC Chair, and recent judicial decisions undercutting the agency's authority to issue net neutrality rules were regarded by many as signals that U.S. net neutrality policy would likely reverse course again. But these developments were preempted by a court decision invalidating the reinstated rules as beyond the FCC's authority (U.S. Court of Appeals for the Sixth Circuit, 2025).

Arguably driven by the intent to prevent regulatory fragmentation within the Digital Single Market (Marcus 2016, pp. 265-270), in 2013, the European Commission (EC) issued a proposal for a regulation that subsumed network neutrality regulations, aiming to implement enhanced transparency rules and a regulatory market split that contained strict network neutrality regulations. After a series of Member States considered implementing their own network neutrality regulations, with Slovenia and the Netherlands famously introducing national legislation, the European Commission (EC) strongly deviated from its initial position just a few years earlier by adopting the Open Internet Regulation (OIR) in 2015 (European Union, 2015). It reinstated harmonization among net neutrality regimes within the EU member states. The Body

[1] Tim Wu is credited with coining the term "network neutrality" in a speech at a 2002 conference that was published in 2003 (Wu, 2002, 2003). The following year, the same conference and journal invited one of the authors of this article to provide a response and provided Wu with the opportunity to offer a rebuttal (Yoo, 2004; Wu, 2004).

[2] The FCC's December 2010 adoption of formal rules was preceded by Chile's adoption of the first net neutrality law in July 2010, although Chile's law has yet to be enforced.

of European Regulators for Electronic Communications (BEREC) has issued guidelines to inform and coordinate National Regulatory Agencies' (NRAs') enforcement of these rules (BEREC, 2016, 2020, 2022). Other countries outside the EU and the U.S. have adopted similar regulations (Garrett et al., 2022).

The U.S. and European rules attempted to strike a balance between limiting last-mile ISPs' ability to restrict traffic with the need to manage their networks to ensure its security and integrity as well as the benefits from offering innovative new services. To address these concerns, both the U.S. and European regimes included exceptions for "reasonable network/traffic management" designed to give ISPs the flexibility to ensure network security and integrity, curtail traffic unwanted by end users, and to manage congestion. Both regimes also included an exception for "specialised services" optimized for the needs of applications that demand higher levels of quality of service, such as Internet Protocol television (IPTV), voice over LTE (VoLTE), videoconferencing, and real-time health services.[3]

Over time, the debate has placed greater emphasis on net neutrality's impact on incentives to invest in network infrastructure. The potential for mandated openness to stimulate investment played a key role in justifying U.S. rules. In the initial 2010 Order, that dynamic was acknowledged to be based largely on speculation. The proceedings that led to the 2015, 2018, and 2024 Orders placed increasing emphasis on empirical evidence of the impact of net neutrality regulation on investment incentives, particularly after the FCC began relying on a statutory provision focusing on infrastructure investment as the legal authority for its actions. In Europe, the long-awaited report on *The Future of European Competitiveness* authored by former European Central Bank head and former Italian Prime Minister Mario Draghi (2024a) warned that overly restrictive ex ante regulation is dampening the incentives to invest in the broadband connectivity that Europe needs to succeed.

Despite the increasingly pivotal role that net neutrality's economic impact plays in justifying its imposition, the empirical literature assessing that impact remains sparse. This is remarkable, as net neutrality regulation represents a strong form of market intervention. The lack of clear evidence of net neutrality's consequences for the main economic actors in the Internet ecosystem (CPs, ISPs and consumers/end-users) makes it all but impossible to assess whether the intervention creates benefits sufficient to justify the high implementation, monitoring, and enforcement costs that net neutrality entails. The contentious and often ideologically charged

[3] U.S. law initially used the term "specialized services" (FCC, 2010). It later used the term "non-BIAS data services" to refer to the same type of offerings (FCC, 2015, 2024).

nature of the net neutrality debate over the past two decades only increases the importance of ensuring that any policy intervention be based in evidence.

This article aims 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 since major policy changes in 2015 and 2018, respectively?

Addressing these research questions should enhance the policy discussions in Europe, the US and other developed countries. This is particularly important in the context of wireless networks, whose greater susceptibility to interference and congestion creates greater need for network management (Yoo, 2016). Moreover, the faster speeds, greater capacity, and lower latency offered by the ongoing deployment of the new 5G mobile networks also depend on virtual networks and network slicing, whose 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 outline 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 describe 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 of the 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 descriptive analysis, contrasting recent developments in EU mobile broadband markets with the situation in the US and other jurisdictions that have adopted net neutrality policies that differ from those adopted by the EU. Our final Section 6 summarizes and outlines the main policy recommendations for the ongoing policy debate.

2 Institutional background

The information and communication technology ("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 CPs such as Apple, Microsoft, Amazon, Google (now Alphabet), Facebook (now Meta Platforms), and Netflix, 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, many of which are interconnected via private global network infrastructures.

These changes in ICT ecosystems have also been accompanied by fundamental shifts in market power. In the "old" world, so-called incumbent telecom operators ("telcos") such as AT&T, Deutsche Telekom, or Telefonica long enjoyed a strong and legacy infrastructure-based position of market dominance in pre-defined electronic communications markets.[4] These telcos and other broadband access Internet service providers (both hereafter referred to as ISPs) now confront CPs with strong bargaining power derived from the high popularity of their applications and services. This rebalancing of market power within the ICT ecosystem is also clearly reflected in the evolution of market capitalization: As of November 2024, the market capitalization of the six largest U.S. technology giants was roughly USD 12.7 trillion, with Chinese companies Tencent and TikTok parent ByteDance being valued at an additional USD 0.5 trillion and USD 0.3 trillion (Companies Market Cap, n.d.a; Wang and Shah, 2024). Indeed, each of these five U.S. companies ranked among the seven most valuable companies in the world (Apple USD 3.5 trillion, Microsoft USD 3.1 trillion, Amazon USD 2.1 trillion, Alphabet (Google) USD 2.0 trillion, and Meta (Facebook) 1.4 trillion). Any one of these companies by itself exceeded the market capitalization of all publicly traded European ISPs (USD 0.3 trillion) and all publicly traded U.S. ISPs (USD 0.9 trillion) combined (Companies Market Cap, n.d.b). The dynamism of this development is also remarkable given that most of these and other CPs were established only after the early phase of telecommunications market regulation some 15–20 years ago.

At the same time, the profitability patterns that underpin the CPs' high market capitalisations contrast sharply with the continuing high investment requirements and declining or stagnating

[4] The term incumbent typically refers to former state-owned and fully integrated telecommunications operators deemed to have significant market power deriving from monopoly-like control over 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.

revenues confronted by the ISPs. While average revenues per user ("ARPU") in the fixed-line sector has stagnated at around €21.9 per month over the past decade, ARPU in the mobile sector has gradually declined from €16.2 to €14.6 per month (ETNO, 2023, p. 38). This contrasts sharply with ARPUs in the U.S. and Canada, which remain at more than double the levels and have declined at less than a third of the rate in Europe (OECD, 2024, pp. 10–11; Draghi, 2024b, p. 69). This decline in revenues resulted from 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, and Facetime, which are available at no extra (monetary) cost to consumers. This has increased data traffic on telco networks, whilst simultaneously shrinking average revenues for mobile networks.

According to the European Commission (EC), full gigabit coverage across the European Union (EU) as well as 5G coverage in all populated areas would require an additional investment of up to €200 billion.[5] The EC also notes that investment levels in the EU fall below those of its main trading partners (European Commission, 2023b; see also USTelecom, 2022; Draghi, 2024b, p. 69). The high investment needs in Europe are driven by the continuing growth of Internet data traffic, which is exacerbated by the current OIR framework, which limits operators' ability to manage that traffic in ways that reduce its impact (an effective "must carry" obligation). The ITU reports that mobile broadband traffic in Europe grew at compound average growth rate ("CAGR") of 33% between 2019 and 2022 (ITU, 2023). Industry reports predict that this trend will continue in the future. For example, Arthur D. Little (2023) projects that average mobile data consumption per capita in the EU will grow from 13 GB/month in 2023 to 76 GB/month in 2030, which represents a CAGR of 25%. Nokia (2023) similarly forecasts that aggregate global mobile data traffic will grow from about 100 to 468 EB (exabytes) per month in 2030, a CAGR 22%. Ericsson (2024) projects that mobile data traffic will grow from 145 per month in the first quarter of 2024 to 313 EB per month in 2029, a CAGR of roughly 20%. Industry studies forecast similar growth patterns for global consumer fixed broadband traffic (ITU, 2023; ADL, 2023; Nokia, 2023). Data growth will be driven mainly by various video streaming services, which accounted for 68% of downstream

[5] 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 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.

network traffic both globally and in Europe in 2023 (Sandvine, 2024, pp. 15, 20).[6] Sandvine (2024) reports that five firms—Alphabet (Google), Meta (Facebook), Netflix, Microsoft, Tik Tok—accounted for 51% of global traffic on fixed networks and 61% of traffic on mobile networks. Expanding the total to include Apple, Amazon, and Disney increases those percentages to 66% and 69% respectively (Sandvine, 2024, pp. 5–6).

On the other hand, increased network capabilities will also drive continuous traffic growth. 5G is projected to account for 60% of the world's mobile subscriptions and 75% of the world's mobile data traffic by 2029 (Ericsson, 2024, pp. 4, 11; see also ADL, 2023; Nokia, 2023; Ericsson, 2024). By 2028, all mobile data traffic growth will come from 5G (Sandvine, 2023, p. 22). 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, 2023b, p. 18) and 25% between Q1/2023 and Q1/2024 (Ericsson, 2024, p. 10). Although technological innovations such as content delivery networks ("CDNs") and advances in compression technologies have increased the efficiency of both wired and wireless networks, 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 high definition ("HD") or ultra HD ("UHD") plans or 4K resolution (Sandvine, 2023).

Given the high investment levels required by broadband networks, public authorities in some EU and non-EU OECD countries have begun to consider whether to use state aid to help finance the deployment of new broadband networks, particularly in 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, as demonstrated by numerous contributions to the empirical literature.[7] 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

[6] Under Sandvine's (2024) methodology, streaming includes both on-demand services (e.g., Netflix, YouTube Hulu, Disney+, Apple TV+, or Amazon Prime) and live streaming services (e.g., sports rights being acquired by Amazon or DAZN Group) but does not include video calls.

[7] For reviews of the literature related to broadband networks see Bertschek et al. (2015), Abrardi and Cambini (2019), and Briglauer et al. (2024).

technological 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 constantly forced to expand, upgrade and re-dimension their networks to meet the growing challenge of IP traffic, a controversial debate has emerged on whether regulators should force Big Tech companies to contribute more to help cover the network costs they generate. Fair share officially became part of an exploratory EC consultation launched in February 2023. In October 2023, the EC published a summary report of the consultation that appears to have postponed telcos' calls to implement fair share, with any final decision on whether to proceed not expected before 2025 (European Commission, 2023a). Similar proposals have been floated in the U.S. FCC Chairman (designate) Brendan Carr (2021) has previously published an op-ed advocating requiring CPs to contribute to the universal service fund ("USF"). The FCC report mandated by Congress to reassess how best to reform USF to achieve the goals of universal service to broadband discussed the possibility of requiring CPs to contribute to USF at length, ultimately recommending that Congress enact legislation clarifying whether the Commission has the authority to take such action (FCC, 2022, p. 54). A bipartisan group of U.S. Senators has proposed legislation that would do just that (Bicheno, 2023). Similar discussions are taking place in other countries.[8] 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 monetize their network infrastructure vis-à-vis CPs by imposing binding rules of conduct on ISPs. Debates over both of these considerations are ongoing in the EU, UK, U.S., and elsewhere and are relevant to the quality of modern broadband networks, the infrastructural backbone of the ICT ecosystem.

[8] European Commission (2023a). Korea has borne witness to a three-year legal battle over network usage charges. The legal rulemaking began in April 2020, when Netflix, which is the most popular streaming platform in South Korea, filed a complaint against SK Broadband – a South Korean broadband and TV provider, and a unit of incumbent telco SK Telecom – rejecting SK Broadband's demand that Netflix pay for network usage. In June 2021, a South Korean court decided in favor of SK Broadband and ordered Netflix to make a payment. In September 2023, while the appeal to the Korean Supreme Court was still pending, Netflix, SK Broadband, and SK Telecom announced a strategic partnership that settled the dispute (Strand Consult, 2023). The regulatory debate represents the first case and rulemaking between a domestic ISP and an international CP.

3 Technological and regulatory developments

In Sections 3.1 and 3.2. below we describe the most relevant technological and regulatory developments, respectively, for answering the research question (i). In Section 3.3, we outline interim conclusions and implications for 5G network deployments.

3.1 Technological developments

3.1.1 Content Delivery Networks ("CDNs") 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 that connect backbone networks to the end-users. Figure 1 shows that the current EU-style net neutrality rules focus on only one part of the content delivery chain without restricting the other. It therefore excludes from its scope (or only indirectly impacts) technologies developed by other market participants such as large CPs (Big Tech), which have invested heavily in their own private networks to strategically distributed services (BEREC, 2016, p. 14, 2020, p. 17, 2022, p. 17; FCC, 2015, pp. 5686–87, 2024, pp. 142, 351–52).

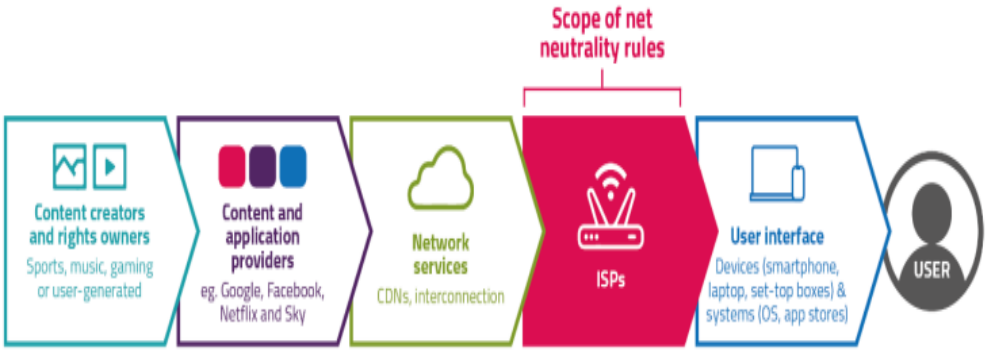

Figure 1: Scope of net neutrality rules in the Internet content delivery chain
Source: Ofcom (2023, p. 19)

Typically, CPs seek to interconnect these private networks with ISPs to deliver content to the end-user. Constructing private networks is not the only solution. In 2021, 61% of the top 1,000 websites and 27% of all websites relied on CDNs to deliver their content (Krishna, 2021). By 2023, already 70% of all Internet traffic (by volume) was delivered through CDNs (Aussieker, 2023).

BEREC guidelines allow NRAs to take interconnection policies and arrangements, such as private peering and access to CDNs/caching, into account to the extent that they affect the user rights protected by the net neutrality rules (BEREC, 2016, pp. 4–5, 2020, pp. 3–4, 2022, p. 4; see also FCC, 2015, pp. 5692–95, 2024, pp. 137–40). These guidelines inevitably require the parties to negotiate any interconnection agreement in the shadow of the provisions prohibiting ISPs from blocking or discriminating against CP content. 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.

The existence of these private networks, including CDNs, introduces a new source of service differentiation that allows CPs bypass the public and regulated Internet (and therefore any net neutrality obligations), as they can manage traffic via these non-regulated private backbones and can host content as close to the end-user as possible to guarantee certain quality levels (Yoo, 2010; Stocker et al., 2017). CDNs are typically deployed by entities other than ISPs and provide a means for service differentiation that do not violate network neutrality regulations. The majority of Internet traffic is already delivered via third-party CDNs such as Akamai or Cloudflare or through distributed service infrastructures of large CPs, which have strongly expanded the number of servers deployed within ISP networks in recent years. By delivering data traffic via their own backbone infrastructures, large CPs can considerably reduce their reliance on the public Internet (Yoo, 2018; Stocker et al., 2017, Stocker, 2020).

From a user experience perspective, these and other mechanisms can serve as technological substitutes for network management by ISPs, providing end users with high quality online experiences, 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 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 finance the cost of self-supplying 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 (Yoo, 2010; Garrett et al., 2022). In essence, the privatization of network infrastructure by the largest CPs and commercial CDNs has the effect of increasing the volume of traffic being managed outside the scope of net neutrality and by market actors that are not subject to those rules.

3.1.2 Private and Hybrid Access Networks

In addition to private core networks, an increasing number of typically enterprise customers are using private access networks to connect their businesses. According to the net neutrality rules, such “non-public” services fall 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” that offer the ability to create a private networking experience 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 (Yoo and Lambert, 2018; Yoo, 2023).

3.1.3 Differentiation-Based Use Cases and Network as a Service

The emergence of 5G and network slicing capabilities allows for a 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 expected to demand higher reliability and low latency as well as local computing via mobile edge computing that is not yet available. 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, which are in the best position to determine what resources their content, service, or application needs, the ability to select the quality parameters applied to their content dynamically 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.[9]

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., Frias and Martinez, 2017; Yoo and Lambert, 2019; Koenig and Veidt, 2023; Yoo, 2023).

3.2 Regulatory developments

3.2.1 EU – BEREC Implementation Guidelines 2016/2020/2022

In contrast to the U.S., the EU has continuously maintained its net neutrality regime since 2015 and published non-binding net neutrality implementation guidelines beginning in 2016 (BEREC, 2016). BEREC updated these guidelines in 2020 (BEREC, 2020). Shortly thereafter, the European

[9] 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., Ericsson (2023a); Vodafone (2023).

Court issued a series of interlinking judgements prohibiting 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 (CJEU, 2021a, 2021b, 2021c). With zero-rating, mobile phone providers were able to distinguish themselves from their competitors and successfully implement a strategy of product differentiation in which they could gain 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 (Yoo, 2017). Consequently, in June 2022, BEREC issued revised guidance on the implementation of the OIR that shifted from permitting popular commercial zero-rating offers provided certain conditions were met to a broad prohibition on all non-application-agnostic forms of zero-rating (BEREC, 2022). This included not just the commercial offers that were the target of the ECJ's judgments but also other forms of zero-rating for public good purposes, such as the zero-rating of consumer support applications 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 programs 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 (Yoo, 2017; 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 zero-rating that promoted the public good, are indicative of the strict approach taken by the courts and regulators to the current EU net neutrality regulations.

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 (BEREC, n.d.). This position encourages an approach of "innovation by permission" only, which again may have a freezing effect on the development of new use cases (Yoo and Lambert, 2019; Yoo, 2023).

3.2.2 UK – Ofcom Statement on Net Neutrality Review 2023

In October 2023, Ofcom (2023) completed a nearly three-year review by issuing 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, by allowing 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 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 has only the authority to provide interpretative guidance and set out its enforcement priorities and cannot amend the underlying UK net neutrality law. 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 benefit end-users, due either to ambiguities in the rules or prohibitions of certain activities. Whilst they stop short of calling for legislative reform, which would fall outside of Ofcom's remit, the guidance highlights the benefits of shifts away from the current prescriptive rule-based system to a principles-based approach 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 step towards a regime with no or only soft net neutrality rules.

3.2.3 US – FCC Open Internet Order 2024

In May 2024, after securing the nomination of the third democratic FCC Commissioner, the FCC released its most recent Open Internet Order once more imposing net neutrality obligations on last-mile ISPs - broadband Internet access service (BIAS) providers in US jargon. Specifically, the 2024 Order reclassified 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 justified its intervention on a range of policy objectives. These include the promotion of competition and innovation, the free speech, national security and law enforcement, cybersecurity, public safety, network resiliency and reliability, consumer privacy and data security, access to BIAS by promoting investment in and deployment of infrastructure and service in multi-tenant environments such as apartment buildings, and access for people with disabilities. At the same time, the FCC downgrades the old innovation protections argument for net neutrality, presumably not least due to the lack of empirical evidence (Section 4.2).

The 2024 Order essentially reinstated 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) rules prohibiting the blocking or throttling of lawful content, applications, services, non-harmful devices attached to the network; (ii) another rule prohibiting paid prioritization (creation of separate "fast lanes") for any third-party or affiliated content; and (iii) a "general conduct standard" banning any unreasonable interference or disadvantage to end users' ability to use BIAS to access services or content or to use devices of their choice or providers' ability to make lawful content, applications, services, or devices available to end users, assessed on a case-by-case basis. All of these rules are subject to the exception for reasonable network management except for the prohibition of paid prioritization, which is subject to a waiver system.

The FCC has indicated that any zero-rating practices would be assessed under the 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 FCC also declined to resolve whether network slicing constituted BIAS subject to the net neutrality rules or whether it fell within the exception for reasonable network management. As in 2015, the 2024 Order carved out enterprise services from the scope of BIAS. It also asserted the authority to oversee the terms under which other networks interconnect with BIAS on a case-by-case basis.

Donald Trump’s re-election signaled that U.S. net neutrality policy was likely to fluctuate once again, particularly given his decision to appoint current FCC Commissioner and outspoken net neutrality critic Brendan Carr as Chair. But before President Trump’s second term began, the U.S. Court of Appeals for the Sixth Circuit (2025) relied on a seven-month-old Supreme Court decision requiring courts to stop deferring to agency interpretations of the statutes those agencies administer to invalidate the 2024 Open Internet Order. This decision appears to have put an end to the vacillating approach to net neutrality that has characterized U.S. Internet policy for the past two decades.

3.2.4 Interim conclusions

Technological developments such as CDNs, private core networks, and 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 open the door to new market-driven bypass strategies. 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 that dominated when the net neutrality debate began 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, 2005, 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 aligns 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. However, BEREC (n.d.) has left clarifying whether network slicing and the 5G Quality of Service Class Identifiers needed to make it work constitute specialised services or reasonable traffic management for NRAs to decide on a case-by-case basis. 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. Regulatory ambiguity and market uncertainty can also lead to inefficient bypass strategies (Vogelsang, 2018).

Ultimately, EU-style net neutrality regulation must confront a dilemma: The law can either create the flexibility that new technologies such as 5G need by adopting a broad interpretation of the exceptions for reasonable traffic management and specialized services, which would make net neutrality regulation less effective, or it can apply these exceptions in a very restrictive manner through lengthy case-by-case decisions, which would inhibit investment and innovation activity, especially in light of the ongoing rollout of 5G and the impending arrival of 6G. The EU's approach raises particular concerns for ISPs that might otherwise be inclined to develop and deploy innovative services but find themselves in a grey zone of compliance and uncertainty.

Figure 2 below summarizes the main developments in net neutrality and zero rating regulation in the EU, UK and US in the last two decades.

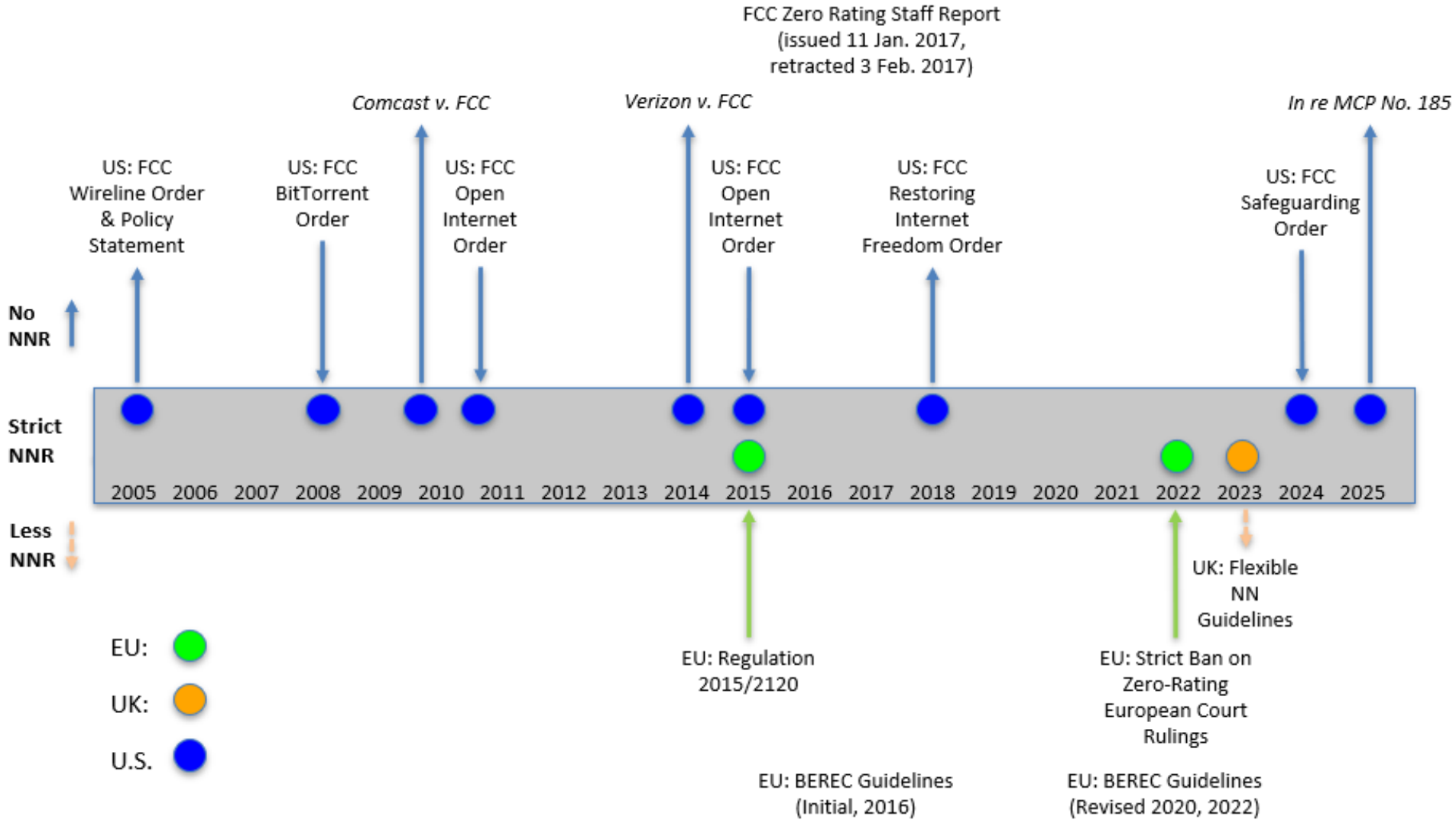

Figure 2: Two decades of net neutrality regulation in the US, UK and EU
Source: Own presentation

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, Section 4.1 only briefly outlines the main approaches and key findings from economic theory models. In contrast, the empirical literature on the subject remains remarkably limited. As a result, Section 4.2 provides a comprehensive overview of it in tabular form. Finally, Section 4.3 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

Schuett (2010), Faulhaber (2011), Krämer et al. (2013), Greenstein et al. (2016), Jamison (2018), Easley et al. (2018), and Hildebrandt & Wiewiorra (2023) provide comprehensive reviews of the numerous theoretical contributions. Most of the theoretical economic literature addresses the impact of network neutrality regulations on market outcomes, mainly through game-theoretic analyses in the context of two-sided markets. 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 conceptualized 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 scenarios in which net neutrality prohibits any price or quality differentiation with scenarios in which ISPs can offer premium service classes for prioritized traffic delivery, typically with access charges. In the latter scenario, ISPs are free to negotiate contracts with CPs. While these models analyze 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., 2023). However, in terms of ISP profits and investment incentives, most models show that net neutrality regulation reduces ISP profits and ISP incentives to invest in new infrastructure (Easley et al., 2018).

Firat and Xingyi (2019) analyzed 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), Jeitschko et al. (2018), Gautier and Somogyi (2020), and Hoernig and Monteiro (2020). These papers identify circumstances under which an

ISP would make greater profits under a sponsored data regime[10] and therefore has an incentive to implement it if it were allowed. All of the aforementioned papers find 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 still scant. 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?

Several empirical papers (4 out of 10) 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. (2023) used OECD panel data and were the first to measure investment activity in physical units, specifically 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 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, the four empirical contributions that found significant results have found a negative impact net neutrality regulation on the investment activities of (wireline) ISPs (Ford et al., 2010; Hazlett and Wright, 2017; Ford, 2018; Briglauer et al., 2023), which is also in line with most predictions in the theoretical contributions. The fact that the available studies use different data sets, with temporal and spatial differences, as well as different measures of investment activity adds to the strength of this inference. This result is further supported by the related empirical broadband literature, which finds a negative effect of

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

different types of sector-specific access regulation on network operators' investment activity (Grajek & Röller, 2011; Briglauer et al., 2018). Three studies (Nurski, 2012; Lee and Kim, 2014; Túdon, 2022) use structural equation or simulation-based estimation models to find that net neutrality regulations ultimately led to negative welfare effects. Finally, one study finds negative effects on mobile app innovation (Layton, 2017), and one study finds insignificant effects on app usage (Bauner and Espin, 2023). Finally, Hazlett (2017) examined the impact of US net neutrality regulation on stock prices and found modest negative effects on side of ISPs. CPs, arguably the intended beneficiaries of the regulations, were unaffected.

To the best of our knowledge, there are only two empirical studies that examines the impact of zero-rating. One is 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. The other study is conducted by WIK (2024). Based on the monthly tariff data collected by WIK from 32 mobile phone providers for May 2021 to June 2023, the authors examine whether the abolition of zero rating had a statistically significant effect on the data volumes included in the tariffs and how strong this effect was. In contrast to RTR (2019), the authors found that in connection with the ban on zero-rating, the data volume included in the corresponding tariffs has increased significantly. In price categories 1 (≤ € 29.99), 2 (> € 29.99, ≤ € 39.99) and 3 (> € 39.99), the data volume has increased by around 480 MB, 3.5 GB and 14.1 GB, respectively.

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, so far, there is no empirical evidence supporting the positive effects claimed by net neutrality proponents. In a way, this finding was confirmed by the FCC in its Restoring Internet Freedom Order in 2024. The FCC first extensively criticizes the work of George Ford for various methodological issues, before turning to the work of Briglauer et al. (2023) as "the only other paper in the record that uses rigorous analytical methods and data to evaluate the impact of open Internet regulation on investment" (FCC, 2024, ¶ 296). That said, the FCC also rejects the findings of this paper on several methodological issues that raise serious concerns in view of FCC.

Reviewing the available literature, FCC (2024, ¶ 302) finally concludes: "The theoretical literature, empirical studies, and commentary are all inconclusive." Although empirical studies can certainly always be criticized in a social science context, the question of what is the available empirical basis for decision-making also always arises in competition and regulatory policy decisions. Making decisions against this basis by pointing out that they are not sufficiently conclusive or subject to methodological flaws or even by pointing out that there is no evidence to expect a clearly negative impact of a planned regulatory measure is highly questionable, as any regulatory market intervention could be justified on the basis of such a line of argument.

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.**
Hazlett (2017)	Descriptive analysis and OLS regression	Daily stock prices S&P 500 Index	31 Dec 2013- 4 May 2015	**n.c.**	**n.c.**	**n.c.**	**-/~**
Layton (2017)	Descriptive analysis and OLS regression	Micro-level data Mobile App downloads per day in DK and NL	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	6 Jan 2014–6 Apr 2014	**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.**
Briglauer et al. (2023)	FE, IV estimation	OECD country-level data Real investment in fibre-based broadband lines	2002–2021	**-**	**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); 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

5.1 Trend analysis

This Section presents key and policy-relevant developments in the mobile communications sector in the period 2008–2023 in descriptive form. The underlying analysis period covers the most important decisions and changes in net neutrality policy among the group of highly developed countries. In addition to the demand-side subscription figures, supply-side figures on investments (5G coverage and CAPEX) 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 representing a jurisdiction with strict regulatory measures formally implemented in 2015,[11] (ii) Asia Pacific, consisting of Japan, which implemented net neutrality regulations in 2007, albeit in a relatively light-touch manner); Korea, which has enforced net neutrality through interpretation of legislation enacted in 2020; and Australia and New Zealand, which have never implemented net neutrality regulations; (iii) Latin America, consisting of three countries that have all adopted net neutrality—Chile (2010), Colombia (2014), and Mexico (2014)—and one that has not but whose authorities have indicated support for the principle; and finally (iv) the United States, which had a comparatively strict net neutrality regime during 2015–2017, and a complete withdrawal of these rules in 2017–2024 (Garrett et al., 2022), and Canada, whose regulator issued a series of decisions in 2017 supporting net neutrality but allowing differential pricing.

Figure 3 shows that mobile broadband subscriptions grew steadily in all regions. However, mobile broadband subscriptions grew more slowly in Europe and Latin America, which are the regions with the strongest net neutrality regulations.

[11] The OECD category for Europe includes the 27 EU countries excluding Bulgaria, Croatia, Cyprus, and Malta as well as Iceland, Israel, Norway, Switzerland, Turkey, and the UK. Five of the six non-EU member states have adopted net neutrality on slightly different dates: Israel (for wireless in 2011, for wireline in 2014), Iceland (2014), UK (2016), Norway (2017), and Switzerland (2014 with an effective date of 2021). Turkey has not enacted net neutrality.

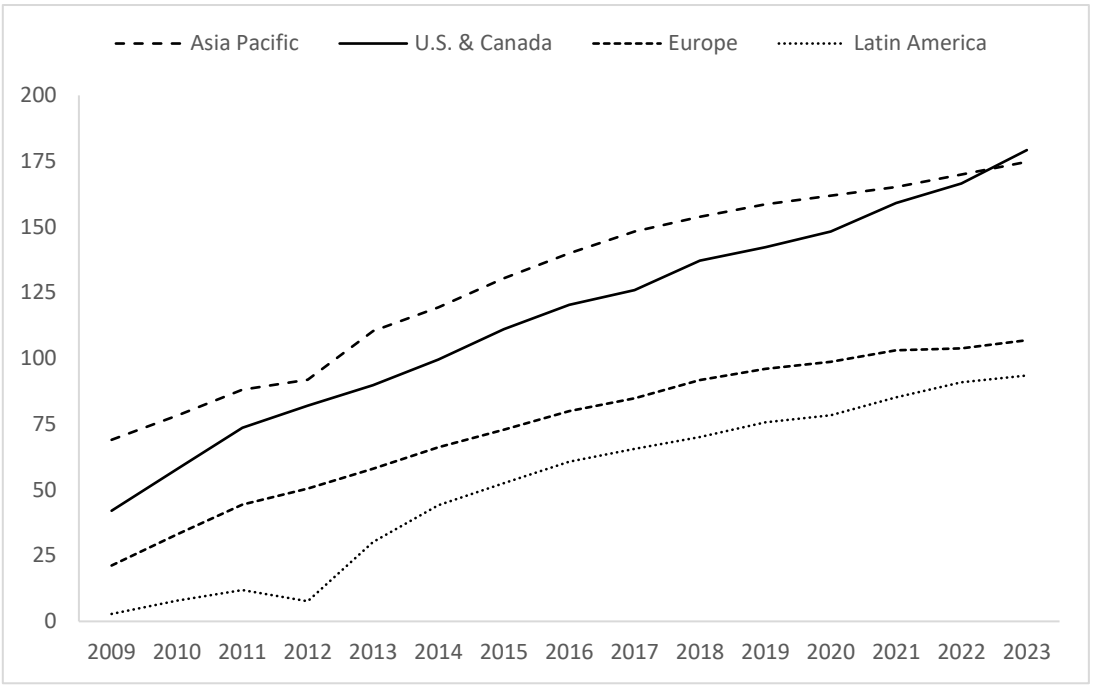

Figure 3: Number of mobile broadband subscriptions per 100 inhabitants for OECD countries by region, 2009–2023
Source: OECD (2023, n.d.)

Figure 4 depicts the OECD's analysis of the change in levels of capital expenditures by mobile operators through 2023 across four regions—Europe, the United States and Canada, Latin America, and Asia Pacific—compared with the base year of 2008. The analysis is based on data collected from GSMA Intelligence about 132 companies from all 38 OECD countries, which generally consists of the better developed countries around the world. Investment patterns of mobile ISPs reflect much greater variation than aggregate subscription data depicted in Figure 3. Possible causes include the sensitivity of CAPEX to business cycles and the CAPEX peaks associated with transitioning to newer generations of mobile technologies (i.e., 3G to 4G to 5G) (OECD, 2024, pp. 16–17). This analysis also finds considerable regional variations in capital expenditures, with Europe increasing CAPEX only 38% since 2008, as compared with a 45% increase in Asia Pacific, a 72% increase in Latin America, and a 76% increase in the U.S. and Canada.

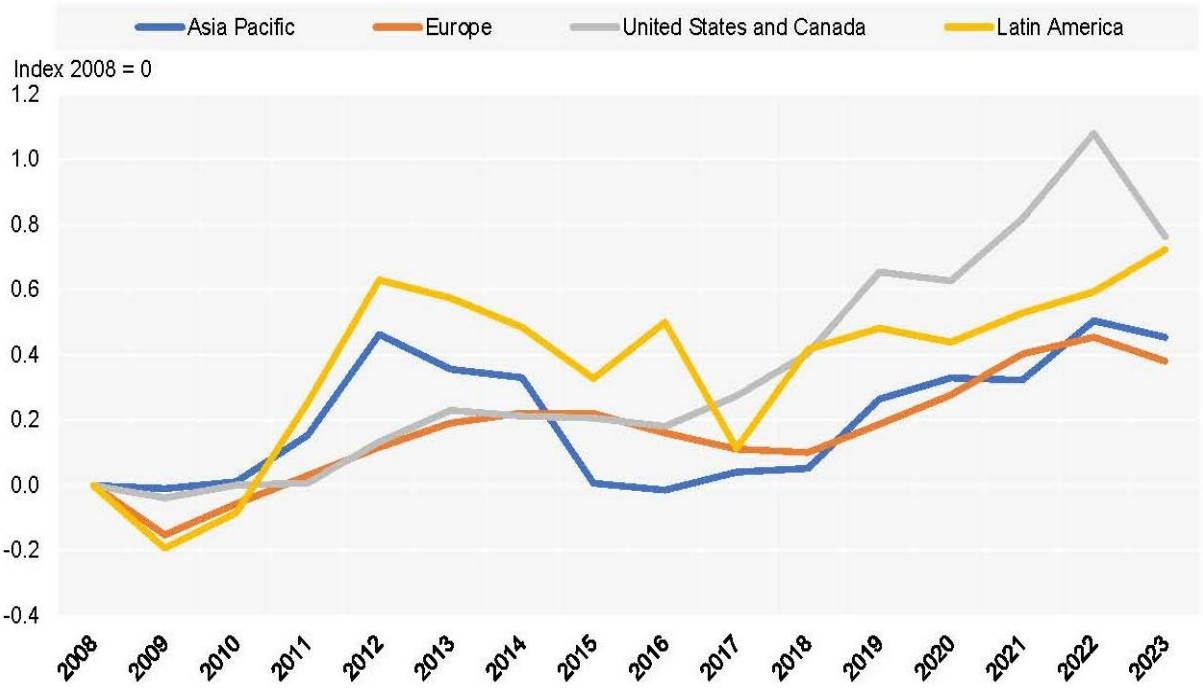

Figure 2: Indexed values of mobile operator CAPEX for OECD countries by region, 2008–2023
Source: OECD (2024, p. 18)

In terms of assessing the impact of net neutrality regulation, CAPEX in the U.S. appears to have taken an upswing beginning somewhere around 2017. Several factors complicate determining whether this change can be attributed to the change in U.S. policy. As an initial matter, the regions included in the OECD analysis combine Canada with the United States, which is problematic because Canada has not at any point formally adopted net neutrality, although the CRTC began issuing decisions consistent with net neutrality in 2017. Pinning down the precise data of the effect is complicated by the fact unfolding nature of the process of repealing the net neutrality rules: The proposal to repeal the rules was adopted on 18 May 2017, approved on 14 December 2017, released on 4 January 2018, went into effect on 11 June 2018, and was not approved by the courts until 1 October 2019.[12] In addition, anticipation effects could have arisen even earlier, as the earlier drafts of the proposed repeal doubtlessly circulated prior to May 2017. Indeed, Trump's outspoken criticism of net neutrality arguably made its repeal likely as early as 8 November 2016, the day he was first elected President. Notwithstanding the uncertainty around inferring any causal effects, the pattern of CAPEX spending by U.S. mobile providers is consistent with the findings in some empirical studies that net neutrality regulation deterred investments in network infrastructure.

[12] Even then, the courts ordered a minor remand that required further action that the FCC did not complete until October 27, 2020.

The timing of the EU's OIR's adoption on 25 November 2015 raises similar questions. CAPEX spending by European mobile operators appear to begin flattening in 2014 before tailing off in 2016 and starting to recover in 2019. The initial flattening might be related to the fact that President Jose Manuel Barroso first proposed the OIR as part of his "Connected Continent" package in his 11 September 2013 State of the Union address and the European Parliament first approved the package on 3 April 2014.

5.2 Interim conclusions

Obviously, the market variables, such as network investment, 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 U.S. (OECD, 2018). Even if the analytical value of descriptive time series comparisons is limited, there is prima facie no obvious negative evidence for the US deregulation policy in 2017 as predicted by proponents and, conversely, no obvious positive evidence for the introduction of the EU regulatory regime in 2015.

6 Final conclusions and policy recommendations

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 promote 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). Regarding welfare effects, our assessment of the current literature is that there are no empirical studies or evidence from trends in key mobile broadband indicators that would support the arguments of proponents of net neutrality policy.

In terms of both efficiency and effectiveness, the "first best" policy recommendation would therefore be to remove obvious over-regulation that impedes investment, such as net neutrality rules. This option would lower institutional costs and might also be complementary to models that would support the public funding of network infrastructure, such as being considered in the U.S. and EU. It also responds to a growing concern about ex ante regulation, as expressed, for example, in the Draghi report (Draghi, 2024b). The outcome of the 2024 U.S. presidential elections suggests that the U.S. may once again deregulate net neutrality altogether. This corresponds to our first-best recommendation.

The "second best" policy recommendation in terms of political feasibility is to provide broadband Internet access services (ISPs/BIAS) more flexibility either in terms of 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. The recent decision of the UK regulator Ofcom represents a step in the right direction in terms of our second-best recommendation, albeit a small and cautious one.

In terms of a future research agenda, much more empirical evidence is needed on the impact of net neutrality rules on content innovation, usage, and consumer prices given that the underlying regulation and the current controversial debates and decisions in Europe and the U.S. have been largely driven by ideological views and political economy considerations in a largely economics- and evidence-free zone. For example, future research should examine the quasi-natural

experiment underlying the diametrically opposed changes in U.S. net neutrality policy resulting from the outcomes of the past few presidential elections. Similarly, the impact of net neutrality rules (including zero-rating decisions) on relevant mobile broadband market outcomes is another area that merits further empirical study. The implementation, monitoring, and enforcement costs and potential market distortions, including market uncertainty due to compliance grey areas and lengthy case-by-case decisions, counsel against imposing net neutrality in the absence of evidence demonstrating benefits that could justify incurring those costs.

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