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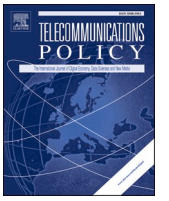

Delivering content: Modular broadcasting technology and the role of content delivery networks

Helle Sjøvaag [a,*], Ragnhild Kr. Olsen [b], Raul Ferrer-Conill [a]

[a] Department of Media and Social Sciences, University of Stavanger, PO Box 8600, 4036, Stavanger, Norway
[b] Department of Journalism and Media Studies, Oslo Metropolitan University, PO box 4, St. Olavs Plass, 0130, Oslo, Norway

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ABSTRACT

Television distribution has changed profoundly over the past 10–15 years. Now increasingly geared towards streaming, broadcasting's value chain hinges on content delivery networks (CDNs) to reach audiences. CDNs are important for content quality, as they constitute the part of the chain that stores and transmits data from broadcasters to the end-user. In this article, we investigate what this value chain shift means for television distribution in Norway, a country where global actors like Akamai and Amazon's CloudFront dominate the CDN market. Based on seven whiteboard-based, co-creation sessions with 15 industry experts representing broadcasters, telecoms, regulators and interest organisations, a value chain analysis reveals that the distribution part of the chain is outsourced and modular. As the technology of television distribution becomes increasingly outsourced, we ask what this means for television's autonomy as a universal service provider.

1. Introduction

Television is adapting to a new environment (Van Esler, 2016) – sometimes referred to as post-tv (Strangelove, 2015), or a 'post-broadcast era' (Meese, 2020; Tay & Turner, 2008) – in which distributors and broadcasters have become more and more reliant on cloud services and content delivery networks (CDNs) to reach end-users. CDNs are essentially scalable architectures of cache servers that store replicated copies of content at multiple locations at the edge of networks (Stocker et al., 2017). These servers are then used to distribute content to users faster and more reliably. Considering that most CDNs are owned by third-party service providers, we argue that the digitalisation of media production and distribution has led most broadcasters to no longer be the sole proprietors of distribution technology in the form of broadcast relay stations, transmission transmitters, and repeater towers. Contemporary television distribution is now increasingly referred to as 'delivery' (Chalaby & Plunkett, 2021), outsourced to major technology companies such as Akamai, Lumen or Amazon Web Services (AWS) that provide playout, security, and analytics to media companies (Johnson, 2021). Various forms of on-demand and online services (such as over-the-top (OTT) video content) that operate alongside legacy broadcasting have not only challenged the role of 'channels' as a format for content packaging and industry strategy for segmentation and marketing (Doyle, 2016); they have fundamentally moved television away from scheduling to curated databases, transforming content workflow to external providers for encoding, storing, transferring, encrypting, and distributing media content (Chalaby & Plunkett, 2021). The debate about what television currently is thus spans ontological questions (Lotz et al., 2018), involving issues of policy and regulation

* Corresponding author.
E-mail addresses: helle.sjovaag@uis.no (H. Sjøvaag), ragols@oslomet.no (R.Kr. Olsen), raul.ferrerconill@uis.no (R. Ferrer-Conill).

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(Just, 2022), business practices and competition (Doyle, 2018; Evens & Donders, 2018), and value chain reconfigurations (Chalaby, 2017; Ramasoota & Kitikamdhorn, 2021; Stocker & Whalley, 2018). Overlooked among these issues is the question of television's autonomy from or dependence on technical domains delivered by third-party operators such as CDNs. As the distribution process becomes more outsourced and modular, the television content delivery model grows increasingly complex. The aim of this article is to uncover what this displacement of national infrastructure in television's value chain means for the autonomy that broadcasters have in the provision of universal service.

This study explores what this shift means for television's autonomy in Norway, a country where broadcasting is subject to universal service provision (cf. NRK 2023; The Government of Norway, 2023). Universal service is the public policy of spreading communication to as many members of society as possible, based on the belief that connectivity has overall societal benefits (Noam, 1997, pp. 955–975), whether it refers to telecommunications, broadcasting, or postal services. Universalism is more based on conduit, quality, affordability, and availability than content as such (Lievrouw, 2000; Verhoest, 2000); and is thus predominantly associated with market concerns (Simpson, 2004). In a broadcasting sense, however, universal service refers to the ability of licensed broadcasters to contribute to social, political, and cultural citizenship (Collins et al., 2001; Harrison & Wessels, 2005), on all platforms (Martin, 2021). Universal service for broadcasters and telecoms alike is thus an obligation to ensure that service is available to all, motivated by the public good quality of information. In Norway, universalism is therefore embedded in licensing remits for distribution technologies such as digital terrestrial television (DTT) and the electromagnetic frequency spectrum (mobile broadband) (cf. Meld.St. 28 (2000–2001); Storsul, 2008). Universalism is operationalised in the Norwegian constitution (§100 on freedom of expression), in the Broadcasting Act (LOV-1991-12-04-127; FOR-1997-02-28-153), and in broadcasters' bylaws (NRK, 2023; TV 2, 2023) as public service media accessible to all. Universalism is furthermore attained through the cable operators' must-carry obligations to transmit public service broadcasting signals, and through the licensed terrestrial transmission system (DTT) (FOR-1997-01-28-153).[1] Overall, it is the responsibility of the state to ensure that there is an infrastructure for open and enlightened public debate (§100), generally operationalised through universal provision as established in the Broadcasting Act.

While recent scholarship has considered what social media platforms mean for universal service provision (e.g., Nikunen & Hokka, 2020; Van Es & Poell, 2020), little attention has been paid to how universalism is affected by the vital role that CDNs play in broadcasting's distribution. This is particularly important because the realisation of universality becomes increasingly dependent on distributors with no public service obligations. Legacy actors such as telecoms and nationally owned DTT still serve as key providers of infrastructure in television distribution, but CDNs enter the value chain without remit. Moreover, universality provisions for internet and communication services do not extend beyond the open internetEcom Act (LOV-2003-07-04-83); and do not include CDN services (cf. Fitzgerald, 2019; Just, 2022; Stocker et al., 2017). While terrestrial transmission (DTT) is remitted to ensure universal service in Norway, DTT frequencies are being shifted toward mobile and 5G (Meld.St. 28 (2020–2021); Nkom, 2023), moving state-controlled television delivery resources towards broadband technology.

After the widespread adoption of networked and on-demand video, television distribution models tend to negotiate multiple competing institutional goals and logics. The logics of public service and universalism (cf. Benson et al., 2018) thus face challenges from networked (Uricchio, 2009), algorithmic (Hadida et al., 2021) logics of distribution whereby technological infrastructures influence institutional goals (Constantinides et al., 2018). Most broadcasters and news organisations today rely on CDNs to deliver video, text, and dynamic web content to their users (EBU, 2022). In this study, we focus on these CDN services for three reasons. First, CDNs are one of the main components of modern audiovisual content distribution. Without them, on-demand television could not exist. Second, in the Norwegian context, CDNs are an unusual link in the distribution chain since they are primarily owned by non-Norwegian actors, which is uncommon for the Norwegian market Sjøvaag, H. & Ferrer-Conill, R. (2024).). And finally, while CDNs have become a standardised and naturalised part of television distribution – "an important element in the process of getting audiovisual content and services to users over the internet" as the bandwidth needed to stream media content is "significant" (EBU, 2022, p. 4), research has largely ignored what this naturalisation means for television's autonomy in the digital communication infrastructure.

While CDNs emerged in the mid-to late 1990s as a solution to distribute content through overlay networks on top of the internet's basic packet transport infrastructure to avoid network congestion (Benghozi & Simon, 2016; Yin et al., 2020), they have risen to prominence as subsea transatlantic fibre cables expanded internet capacity (Stocker et al., 2017). Moreover, as the public moves consumption online (cf. Mikos, 2016), their demand for high quality television delivery also shifts service universality to the internet. The overarching research question we pose is thus: What does the outsourcing of distribution to CDNs mean for television's universal service provision?

To understand the role that CDNs play in the distribution of television in Norway, we have conducted an actor-oriented industry analysis using a procedure we refer to as 'whiteboarding', a new method developed specifically for this research (see methodology section). Through a series face-to-face conversations with broadcasters, telecoms, regulators, and industry organisations, we have mapped out the television value chain within the delivery ecosystem as it looks from the actors' perspectives, using whiteboards and other visual resources as a collaborative generative exercise. Our data, consisting of photo series of the collaborative process of sketching out value chains as they emerged during these conversations, reveal a complex and modular distribution layer wherein

[1] For the commercial public service broadcaster TV 2, universalism is operationalised through its streaming platform TV 2 Play, where TV 2 is obligated to ensure its services have universal reach also through third-party delivery (4.2.4 in TV 2's agreement), covering both live and on-demand streaming. Unlike NRK, the publicly owned Norwegian Broadcasting Corporation, TV 2's public service obligations (including its universality obligations) are limited to its main channel (subsidiary niche channels are except from public service demands), whereas NRK's entire offer is subject to universal provision (§15 in NRK's bylaws).

actors participating in various parts of the chain describe CDNs as essential in television delivery based on data capacity, scalability, data security, and knowhow. Ultimately, broadcasters have 'no choice' but to use CDNs for content delivery, a situation that highlights the lack of autonomy on the part of broadcasters over the infrastructure that supports universal service provision.

This is a problem for three reasons. First, it establishes reliance on a distribution system that is not subject to must-carry obligations, embedded in the universal provision of public service broadcasters to ensure that their content reaches all citizens. Second, while public alternatives exist in digital terrestrial transmission (DTT), broadcasters still need CDN services to ensure quality and capacity in television delivery. And third, as universalism also supports Public Service Media's (PSM) preparedness remit to ensure that information can reach citizens in times of crisis, CDNs assume a key position in the critical infrastructure. Universalism cannot be upheld without oversight and regulation. The reliance on CDNs thus render broadcasters less autonomy over the infrastructure at their disposal in fulfilling the universal remit. Ultimately, while everything may work fine in normal times, there is no telling what will happen if markets concentrate, actors exit the market, or a major crisis occurs. Such concerns are part of the motivation for regulating private actors in legacy telecom and cable sectors. We argue that these regulatory concerns should extend to the CDN sector for the same reasons, so that policymakers can consider and address the risks of infrastructure capture outside of national borders.

2. Television's modular distribution model

We adopt the value chain as our conceptual approach to study television distribution because it allows us to look at production in its various stages, identifying key players, processes, and resources needed to get a product to market (Porter, 1985). The value chain hence entails the expression of a distribution infrastructure to which our study contributes. Value chain analyses have been applied to study how new technology such as broadband and mobile have impacted the television industry (e.g., Prario, 2007); to map out the infrastructure for television distribution in the online realm (e.g., Chalaby, 2016; Johnson, 2021; Ramasoota & Kitikamdhorn, 2021; Stocker & Whalley, 2018); and to understand the formation of strategic partnerships as the value chain turns into value networks (Evens, 2010).

The exact composition of the television value chain depends on the landscape surveyed and the context of the object of study. Chalaby (2017) includes three layers in his global value chain of content – production, distribution, and aggregation. Ramasoota and Kitikamdhorn (2018) mobilise five steps in their analysis of Netflix in Thailand, including content creators, content aggregators, broadcasting network providers, broadcasting facility providers, and devices. Johnson (2021) uses seven layers in her analysis of the online TV value chain, comprising content production, sales and licensing, marketing, delivery, consumer electronics, software development, and technological infrastructure. The television value chain, in its most basic components, thus consists of content producers, broadcasters, distribution services and hardware before reaching the end-user. We operationalise content producers as the creators of content such as production companies and movie studios and the owners of intellectual property rights. Broadcasters are operationalised as aggregators of content such as TV channels, broadcasters, and streaming platforms. Distribution is operationalised as the technology used to deliver content, including IPTV, DTT, cable, satellite and CDNs. Hardware is operationalised as the equipment receiving television signals such as cable receivers, Set-Top Boxes and Apple TV devices, while the end user is the audience. Our operationalisation is an analytical one in the sense that we depart from the research question and design the value chain pragmatically, using the components necessary to discuss the role of CDNs in television delivery given our empirical focus. Hence, certain chains used (e.g., by Johnson, 2021) such as sales, licensing and marketing are less important, while a nomenclature like aggregation (e.g., Chalaby, 2017) is less relevant than broadcasting.

To be clear, there are multiple distribution systems that bring television signals to audiences. Satellite TV entails transmission of television signals through satellites received either through antennas or relayed through ground stations through coaxial cable networks to the home. Cable TV transmits signals directly over coaxial or fiber cable networks from the broadcaster to the subscriber. Broadband provides fast internet connectivity that allows the transmission of digital broadcasting signals. In Norway, most of the broadband network is based on fiber optic cables. Digital terrestrial television (DTT) transmits signals using radio frequencies through broadcasting towers to antennas at people's homes, received through a decoder in the house. DTT is then converted to the fiber optic network and delivered in Norwegian household through decoders and Wi-Fi routers. Similarly, IPTV or Internet Protocol Television transmits digital television signals over broadband networks using Internet Protocol transmission, received by a decoder. IPTV enables multicasting, or one-to-many transmission where one sender delivers signals to multiple recipients, different from unicast where signals are delivered one-to-one, used in OTT delivery where signals are delivered individually, on demand, different from live streaming where content is delivered as it occurs. OTT is content delivery that bypasses satellite, cable and DTT and basically means television delivered over Wi-Fi. Traditional broadcast technology is a one-to-all delivery method that transmits the same signal to all receivers on the same network. CDNs primarily use anycast delivery. Whereas unicast delivers signals to a unique IP address, and multicast delivers simultaneously to multiple recipients, anycast allows an IP address to be assigned to multiple, geographically distributed servers. This means an anycast request can be routed to the nearest server, reducing latency, and distributing traffic load across the server network. Thus, CDNs are responsible for routing traffic from a content provider to its own (or third-party) servers, and from those servers to the last-mile internet connection to reach the end-user (Benghozi & Simon, 2016).

CDNs are estimated to carry over 70 percent of internet traffic worldwide (Ghaznavi et al. 2021), the majority of which is video content (Li et al., 2021). CDNs thus offer cost savings and scalability to facilitate peak traffic (EBU, 2022; Ghaznavi et al. 2021), but they are often seen as too technical for broadcasters to develop in-house solutions. As Sørensen (2020) found when he asked the Danish public service broadcaster (DR) about their CDN strategy, they admitted to opting for an external provider, as they did not consider themselves as technologists but rather as content providers. This stands in some contrast to past narratives of broadcasting houses as centres of technological innovation (Chalaby & Plunkett, 2021), as the sole proprietors of distribution modalities (Evens, 2010), and

transmission technology in national media systems (cf. Turner, 2009).

The location of CDNs in the value chain, however, is difficult to pinpoint, resulting in inconsistencies in terminology. Johnson (2021) places CDNs within the distribution layer that manages transmission (including cable, satellite, Wi-Fi, etc.), as well as infrastructure for file storage and computing that also covers data centres and cloud computing. Ramasoota and Kitikamdhorn (2021) also place CDNs under distribution, here described as broadcasting facility providers, while Chalaby (2017) designates CDNs to the broadcasting part of the value chain, here termed aggregation, which includes infrastructure and media services companies and satellite operators alongside CDNs. Frischmann (2012), on the other hand, refers CDNs to the layer of the internet where standards and protocols facilitate data transfer across physical networks, separating these protocol players from the physical hardware that comprise interconnected networks such as cables and satellite networks, data centres, routers, and servers. This suggests there is a difference between physical distribution resources and protocols that most television value chain analyses tend to overlook (cf. Hesmondhalgh et al., 2023). Hence, CDNs encompass transmission technologies (akin to cable or satellite infrastructure), storage and processing facilities (made up of servers), technological standards (so, not server hardware but transfer protocols) and content delivery systems. We place CDN services under the distribution part of the chain, as CDN delivery requires both file storage in data centres and protocols for transmission.

Apart from their position in the value chain, the role of CDNs in television distribution has scarcely been considered in the literature, often mentioned only in passing, or when streaming is the object of research. CDNs are relevant to research on on-demand media because owning or outsourcing delivery will include or exclude external actors in the distribution process, challenging the broadcaster's autonomy. Few studies move beyond the level of content or audience reach to ask what CDNs mean for national broadcasting distribution, or to what extent third-party CDNs, most of whom are owned and operated from the US and China (cf. Chalaby & Plunkett, 2021), displace national infrastructure players in the television ecosystem. This matters because, in most welfare states, core broadcasting ideals are challenged by these commercially driven third parties, including the universal service provision that renders technological autonomy to broadcasting.

In Norway, television signals reach audiences through fiber cable, digital terrestrial television (DTT) and satellite distribution, where fiber access is the dominant technology at 52,8% penetration, followed by coaxial cable-TV (23,8%), satellite (14,5%) and DTT (7,9%) (Meld.St. 28 (2020–2021); Nkom, 2023). These infrastructures are owned and operated primarily by national actors. Comparing this to other markets, Norwegian TV distribution leans towards fiber, compared for instance to the UK, where signals are primarily received through DTT (Ofcom, 2023), as has been the tendency across Europe (EC, 2018). Comparatively, Norway offers the same types of choices in distribution technology as seen in other European markets, however fiber subscriptions are higher in Norway compared to other countries in the Nordic and Baltic region, as is satellite reception, while cable access is lower (Nkom, 2020). Norway is thus a relatively typical case of TV distribution technology choices for users in Northern Europe but leans less on DTT as universal access technology than broadcasters in other markets. As DTT bandwidth is scaled down in favour of mobile broadband (Meld.St. 28 (2020–2021); Nkom, 2023), slated to be phased out by 2030, broadcasters need other solutions to provide quality of service to users and to fulfil their universal service obligations. As technology requirements increase in the age of streaming, media organisations depend on their resources and scale to decide whether they invest in their own technological assets or outsource various tasks to suppliers (Narayan, 2022). While the shift from DTT to mobile is a political decision, policymakers seem to be oblivious to the role of CDNs in online content delivery.

In an OTT environment, the digital infrastructure relies on a layered, modular architecture that increases the ability of an infrastructure to remove any dependence on the producer or distribution network to transmit content (Constantinides et al., 2018). This means that media companies have the ability to break down television distribution into multiple processes that can be carried out individually. While this approach seems to complicate the process, Baldwin and Clark (2000) argue that a modular architecture can reduce complexity and increase flexibility by interconnecting loosely coupled components in the distribution chain. This implies that by adding CDNs, media organisations can expand or contract their operational needs, and decide whether they want to run CDNs internally or outsource it. A modular approach also challenges traditional notions of control and autonomy of distribution processes, which are often critical for the provision of universality. The specialisation of production and distribution in media production leverages different degrees of autonomy to media actors depending on the scale of the actor and its distance from power (Hesmondhalgh, 2006). Small-scale, alternative producers should have more autonomy as they are further away from sources of power. This overlooks "the domination of cultural production by multinational entertainment corporations across all cultural industries" (as noted by Hesmondhalgh, 220), but also misses the central role of technology in the distribution process. In on-demand TV content distribution, technological innovations become integral to the goal of delivering content in a way that is competitive. Modularity solves this problem by decoupling specific technologies from the distribution goal. At the same time, convergence around one type of technology within an industry, such as the use of widespread industry standards such as CDNs, is a worldwide phenomenon (Gómez & Munoz Larroa, 2023; Khalil & Zayani, 2022) that mitigates the influence of media conglomerate ownership (McAllister & Proffitt, 2020) but places it at the hands of tech giants, such as Amazon or Google (Chalaby & Plunkett, 2021), and telecommunications companies (Meese, 2020).

3. Materials and methods

This is an actor-oriented analysis designed to ascertain the role of CDNs in the television value chain as perceived by experts in the field. We employed purposive sampling to achieve these insights. Our aim was to talk to industry actors primarily from the telecom and broadcasting sectors, but we also reached out to relevant regulators. Due to the nature of the broadcasting landscape in Norway, the universe of actors is limited. In the case of broadcasters, we talked with directors of distribution and members of their team. In the case

of telecoms, we talked with heads of peering and distribution. In the case of policy and regulatory actors, we talked with heads of markets and services, technology, and security (see Table 1). We also reached out to global and regional streaming actors such as Warner Bros. Discovery and HBO, but these private actors declined to talk to us. This represents a limitation to our study, as we are not able to assess CDN use among larger streaming services in the region. Nevertheless, we managed to engage most of the relevant actors in the national field, who fall under regulatory sovereignty within the national infrastructure.

Our sample consists of the main telecom operators in Norway, Altibox, ICE and Telenor; the two main broadcasters in Norway, the Norwegian Broadcasting Corporation (NRK) and TV 2, both of whom have public service obligations; the Association of Norwegian Media Businesses, which represents the interests of more than 500 media, IT, and publishing businesses in Norway; and the Norwegian Communications Authority (Nkom). All in all, we talked with 15 people, 13 men and two women, all with extensive (10–20 years) experience, a majority of whom have business or engineering backgrounds. Gender balance was not attainable as we sought technical directors, a segment that happens to be dominated by men.

We approached the informants with a request for an informal meeting, outlining three basic topics for the conversation (the value chain of television distribution, the role of CDNs in the value chain, and the role of regulation). We invited ourselves to their offices and asked that they provide a meeting room with a whiteboard, noting that they could include whoever they wanted from their side in the room. We expressly stated that we would not be recording the meetings. All meetings (except one) were conducted with two or three representatives from the research team – one to steer the conversation and one or two to take notes. The duration of the meetings varied from 60 min to 3 h.

The conversation set-up was designed to get the actors in 'teaching mode', inspired by thinking-aloud methodology whereby the informant is asked to describe their choices and thoughts while completing an assignment (e.g., Someren et al., 1994). In our case, thinking-aloud aimed to capture participants' perceptions of value chain characteristics and dynamics as well as their considerations regarding CDN configurations and strategies. We started by outlining a simplified model of the television value chain (see Fig. 1). We did not specify what specific form of television distribution we were interested in, but rather asked informants to outline the distribution technologies relevant to them. This is reflected in the results, illustrated in the figures, where one (Fig. 2) distinguishes between different technologies (DTT, cable/satellite, IPTV and OTT), whereas the rest (Figs. 3 and 4) refer to IPTV in general. The discussion, analysis and figures thus include both on-demand, live streaming, and IPTV. Then we invited them to the board to elaborate on the distribution part of the chain, to draw CDNs into the value chain as they saw it, and feel free to change or add to the model. As informants explained, pointing to various links in the chain, we would add notes to the board, draw links and add more elements, or remove or change irrelevant ones. The process was thus a co-creative, cumulative procedure until we arrived at a model that represented the value chain as the informants saw it. We took pictures along the way, from the beginning and through every addition of new information to the finished model. In some cases, we took pictures of Powerpoint slides the informants would show to illustrate a particular point in the conversation. All in all, our data consists of 59 pictures and 15 pages of notes.

We summarised the notes and drew up diagrams of the value chain resulting from each of the meetings. Based on thinking-aloud data we also conducted a thematic analysis (Braun & Clarke, 2006) identifying CDN considerations and strategies. Thematic analysis was deemed appropriate for the analytical procedure because it allows for the discovery of patterns and themes from complex industry activities (Chan-Olmsted, 2019). As thematic analysis is driven by the research question, it also provides the necessary analytical flexibility and straightforwardness which suited both our limited sample, unstructured approach, the whiteboarding exercise, and hand notation. Themes emerged by cross-referencing notes and pictures taken during the meetings with informants. While field notes entail a risk of loss in detail (Williams, 2020), this was considered a justifiable sacrifice, given our unobtrusive method. Moreover, field notes also provide details towards a thicker description and are thus useful for secondary analysis, especially when multiple researchers are involved (Phillippi & Lauderdale, 2018).

Informants received a consent form along with the photographic documentation from our meeting, our reconstruction of the value chain, and the data supporting our analysis. We encouraged them to confirm, correct, or expand our interpretation at the end of the

Table 1
Overview of informants.

Sector	Company	Role
Broadcasting	NRK	Head of Distribution
	TV 2	Head of Network and Distribution
		Video Streaming Architect
Telecom	Telenor	Peering Manager
	Altibox	Head of Entertainment
	ICE	Project Lead, Private 5G
Interest organisation	The Association of Norwegian Media Businesses	Head of Insights and Analytics
		Head of Digital Development
		Head of Media Policy
Regulator	The Norwegian Communications Authority	Director of Markets and Services
		Head of Security
		Head of Section, Markets and Services
		Senior Advisor, Internet Governance
		Senior Engineer, Security
		Legal Advisor, Open Internet and Digital Markets

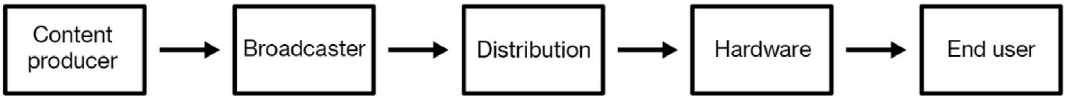

Fig. 1. The basic television value chain.

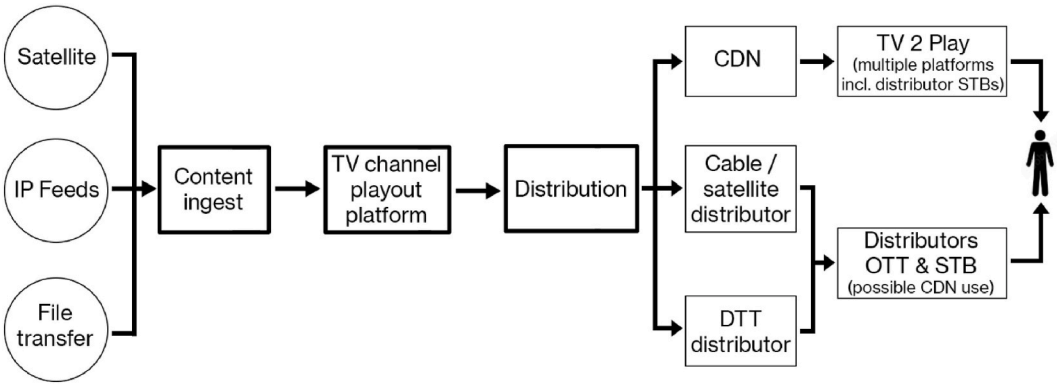

Fig. 2. The television value chain as seen from TV 2's perspective. The boldened boxes represent what was left from our original value chain drawing (see Fig. 1). STB in the distribution part of the chain refers to Set-Top-Box, or the decoder that receives television signals.

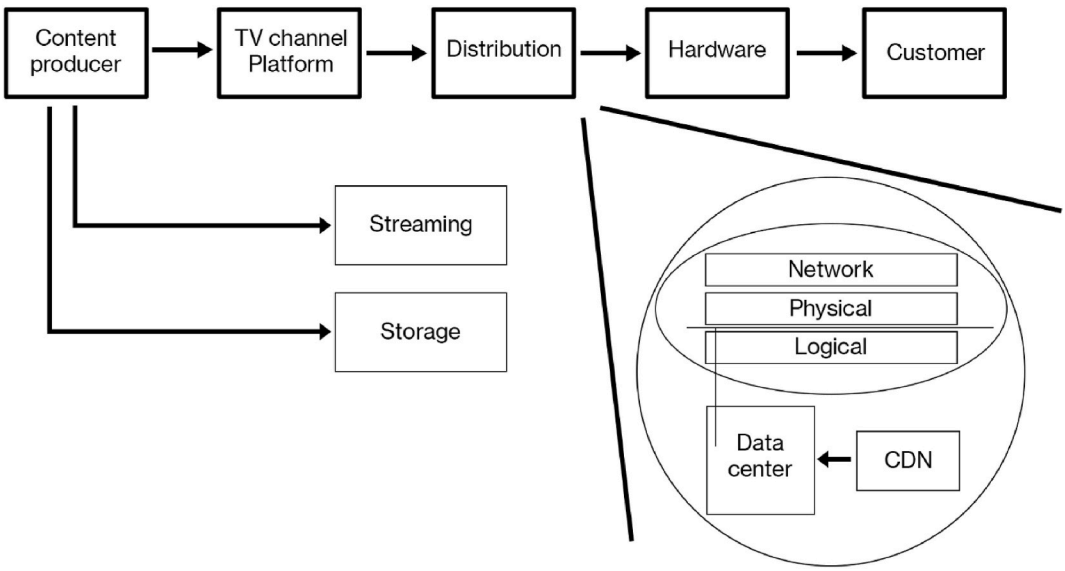

Fig. 3. The television value chain as seen from Altibox's perspective. The boldened boxes represent our original value chain drawing (Fig. 1). The outtake represents the physical and logical layers of the internet.

process. Two informants responded with information that added more nuance to our analysis, which we subsequently included in the text and figures. Data management and privacy was handled in full compliance with the rules of The Norwegian Agency for Shared Services in Education and Research [national research ethics agency anonymised], under project code 722057 [anonymised].

4. Findings and analysis

Our analytical strategy follows a two-step process. First, we provide the results from our initial whiteboarding exercise. Then, we conduct a thematic analysis that incorporates interviews, notes, photographs, and documents as sources of evidence.

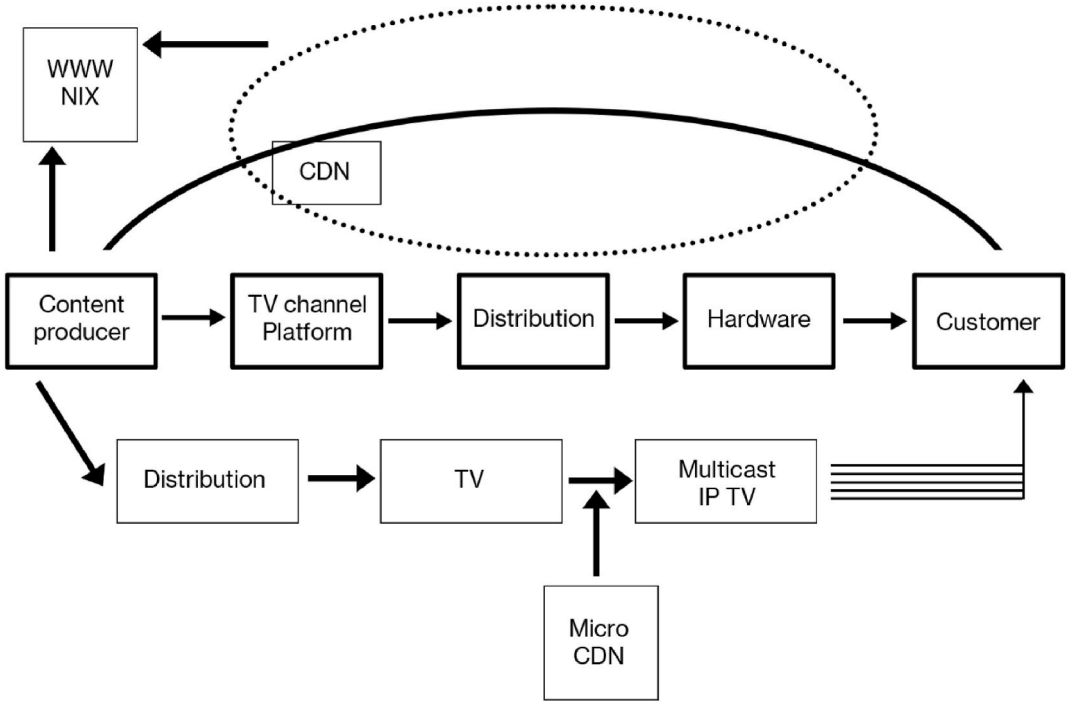

Fig. 4. The television value chain as seen from ICE's perspective. The boldened boxes represent our original value chain drawing (Fig. 1). The 'WWW NIX' box refers to the Norwegian Internet Exchange peering traffic over the world wide web.

4.1. Whiteboarding

Drawing up value chains with our informants shows two overall trends. First, the broadcasting value chain seems to follow the established linear flow with small variations that are contextual. Second, the distribution channels and strategies have become more complex. This complexity is wrapped under the broad spectrum of modularity, in the sense that distribution can assume a variety of paths, and that multiple paths exist together, e.g., the same content can be distributed through the terrestrial network, through cable, through satellite, over the internet (internet protocol, or IPTV) and through CDNs, often simultaneously.

This development is demonstrated in every organisation we analysed. For example, during the conversation with the broadcaster TV 2, the breakdown of their distribution model demonstrated a modular process (see Fig. 2). As a broadcaster with public service obligations, TV 2 uses multiple distribution systems, to most of which, CDNs are important.

One of the main highlights of the collaborative mapping presented in Fig. 2 is that our informants erased the distribution chain and added to the figure a direct link between distribution, CDNs, their own streaming platform, and the receiving player at the point of the user end. When we asked about other forms of distribution, they added cable and DTT (digital terrestrial television), to which CDNs are also used for cable distribution. They drew file transfer, IP, and satellite feeds to their own receiving end (content TV 2 receives from providers). Multiple modules of CDNs can thus be plugged into the system depending on the type of content or the various distribution infrastructures. Hence, while television delivery is available through multiple distribution technologies, CDNs are important in off-loading the strain on origin servers at the broadcaster.

This flexibility and adaptability of CDNs to extend the existing infrastructure is part of their appeal. As our informant from the telecom Altibox explained, CDNs have entered the distribution part of the chain as overlay networks (Fig. 3), placed in data centres, operating between the physical and logical layers of the internet. CDNs are not so much a new link in the chain – rather, they operate on the transmission between distribution and the hardware that receives television signals, operating on 'closed' connections. Hence, as television distribution grows modular, this modularity is also enabled in large part by closed transmission systems on top of the open internet provided by ISPs, important for OTT delivery of broadcasting content over the internet. The distinction between 'open' and 'closed' internet is relevant in this case because while the 'open' internet falls under the prevision of telecom regulations (the Ecom Act), CDNs can be considered 'closed' in the sense that contracts determine the service delivered.

Our informant zoomed in (Fig. 3) on the link between distribution and hardware, representing the internet connection. Whereas this 'internet connection' is characterised as 'open', the outtake represents a 'closed' connection where CDNs rent data centre capacity to distribute content. The informant also stressed the ability of content providers like HBO, Netflix, and Amazon to bypass the broadcasting part of the chain by setting up their own distribution system, often through their own CDNs, e.g., Netflix's Open Connect. Netflix's Open Connect CDN network is noteworthy because the streaming service partners with Internet Service Providers (ISPs) and places physical CDNs within each of the ISPs' networks that join the program.

That ability to bypass the broadcasting phase is something that became apparent in the model drawn by the informant from the mobile operator ICE (a sister company of Altibox). Fig. 4 depicts two parallel value chains in which CDNs are important in both. The top section illustrates where CDNs are positioned on the internet (the dotted circle) as the primary distribution technology for content from the provider to positioned close to the provider, surpassing all other parts of the value chain. In the lower chain, CDNs are important in enabling multicast IPTV. The informant drew two parallel distribution chains, one of the internet (the dotted circle) and one of multicast television. CDNs are key in both distribution systems, where multicast enabling CDNs were described as 'micro CDNs' that deliver content packets in real time, caching content specifically for the content provider, as opposed to regular CDNs that store and transmit content files in 'wanted time', using anycast to reach a single device rather than multiple devices. Both processes are on-demand, but IPTV CDNs deliver packages rather than files, as viewers join the 'stream' from a channel as the decoder casts backwards using multicast.

Three things stand out in particular from this value chain mapping. First, CDNs play a crucial role as key transmission services in the distribution phase of the chain. The operator mentioned most often here is Akamai, the market leader worldwide. Second, distribution has become a modular process that is also heavily reliant on data storage provided by data centres. Not only do CDN providers rent space in data centres that are closer to ISPs (such as Netflix's Open Connect program), but also cloud providers like AWS and Google provide storing backups of video content. Most of CDN architectures rely on a wide array of servers in different locations, owned by different providers, and fulfilling different functions (such as streaming or archiving). This is due to the flexibility to scaling up by increasing data capacity, strengthening security, and acquiring the technical knowhow. CDNs thus not only hold key positions as the creators and managers of transmission; they also occupy central positions facilitating the standards and protocols through which content is distributed (Frischmann, 2012; Hesmondhalgh et al., 2023). There are certainly vertical consolidation processes influencing the television value chain (cf. Johnson, 2021), particularly between the CDN and data centre industries, to the point where it could indeed be argued that CDNs constitute broadcasting facilities Ramasoota and Kitikamdhorn (2021)), but more that this – CDNs have gained an essential role in television distribution, regardless of what technology is used (e.g. IPTV (multicast), OTT (unicast)) to transmit content to users. The centrality of CDNs in distribution means that without it there is essentially no universal service. In the next section we analyse how our informants conceptualise this dependency.

4.2. Thematic analysis

The conversations regarding value chains and CDNs revealed a set of factors that propel the current fragmentation of the TV-value chain and PSM's dependency on commercial CDNs. These can be summarised as service quality, resource, and scale considerations. Regarding service quality considerations, NRK and TV 2 are committed to provide reliable streaming services in competition with global super players like Netflix that largely define the market standards for streaming content delivery. To meet end-user expectations, PSM content must be delivered according to these market standards avoiding inferior user experiences. For video and sound to 'play' properly on end-user's devices, PSMs depend on a distribution layer on top of the internet which can handle increasing volumes of streaming traffic as well as traffic peaks. Thus, service quality requirements in the marketplace for streaming drive PSM towards technological infrastructure that offers a better user experience than the one they can provide themselves through conventional content delivery. CDNs are perceived as technological solutions to an internet capacity problem that prevents streaming from performing efficiently. Transmitting audio from a single point to multiple users though the internet means that a lot of resources will strain the server and will have to compete for bandwidth with other users, reducing the quality of the service. By distributing the access points to CDNs, the access points are distributed closer to the users and can handle the bandwidth, increasing efficiency.

Building and operating proprietary CDNs is described as extremely resource demanding for comparatively small national players like NRK and TV 2. As noted by NRK, having their own CDN would require unjustifiable investment in hardware as well as substantial in-house expertise. Such competency is difficult to recruit and retain due to fierce global competition for skilled personnel in the sector. Resource considerations thus play a central role in NRK and TV 2's decision to outsource this part of their value chain to external CDN providers. Another related consideration is scale. For big global players like Google, Netflix and TikTok it makes sense to have their own CDN to manage their vast amounts of traffic and the capacity and robustness demands that this entails. However, for smaller, national operations, relying on an external provider is described as the only feasible option. This point is emphasised by Telenor, the only national CDN provider in Norway. The legacy telecom runs their own CDN primarily as an integral part of Telenor's internet-based services. To manage the volumes of traffic through these services, avoiding latency and congestion issues, they have built a CDN which is also marketed to external customers, like NRK. However, Telenor does not see itself as a CDN player competing on par with Akamai and other dominant service providers in the commercial CDN market.

Service quality, resource and scale considerations have thus made the broadcasters reliant on external CDN providers. However, they have opted for different CDN configurations, pursuing a multi-CDN and single CDN strategy respectively. NRK have commissioned three CDNs for streaming of content – Akamai, Telenor and GlobalConnect – a decision primarily motivated by service robustness concerns. If one CDN goes down, the two others would still be in operation and secure a stable service to end users. Moreover, three CDNs can handle more traffic than one in instances of extraordinary capacity demands (e.g., during major national live events) as NRK can distribute traffic load at the CDN level. NRKs multi-CDN strategy is also motivated by competition considerations: With three suppliers, NRK is better positioned to compare and negotiate CDN service offerings. TV 2 on the other hand, relies mainly on CDN provider Akamai, perceived to offer sufficient robustness and capacity to meet TV 2's needs even during traffic peaks. Contrasting NRK's strategy of 'not putting all eggs in one basket', running on one CDN infrastructure was seen by TV 2 as more efficient. These contrasting strategies largely reflect the choices facing all broadcasters at the distribution level (EBU, 2022).

5. Discussion

The current state of television distribution in Norway shows similarities and distinctions across the board. The similarities are clearly structural, embedded in the type of demand and the technologies that exist to cover that demand. CDNs thus emerge as the material expression of a networked and modular infrastructure that supports the digital distribution of television content. This industry-wide trend is embraced by all players under study: As technology evolves and the industry converges around distribution solutions (Paul, 2011) all actors are pushed to embrace it as a standard for distribution. What seems clear is that the technology is less relevant, as long as it delivers results. Broadcasters thus depend on the technologies that make the distribution of content perform most efficiently. The modularity of television distribution also facilitates updating the infrastructure in favour of technologies that perform better. The role of CDNs in the value chain is more or less the same across the industry, simply because it is now an integral part of OTT television distribution, evidence of the influence of technology logics within the industry (cf. Constantinides et al., 2018). CDNs make the entire process viable. This shifts the whole question of television distribution beyond the national context, challenging television's technological autonomy (Chalaby & Plunkett, 2021) as well as its institutional logic of universal service (cf. Martin, 2021) as something that is tied to the national market.

The role of CDNs in television distribution also demonstrates an increasing reliance on third-party providers within the broadcasting industries (cf. Constantinides et al., 2018). The autonomy of television, once embedded in their ownership of the technological distribution infrastructure (Evens, 2010; Turner, 2009), shifts from sources of production power to sources of technological power (cf. Hesmondhalgh, 2006; Musiani, 2022). Modularity allows distributors to change technologies and providers more easily than if the entire process was based in a single infrastructural apparatus. While outsourcing distribution processes to third-party specialists constrains media organisations' autonomyFerrer-Conill, R. (2016) , the modularity of content distribution nevertheless allows these organisations to quickly change to third-party providers that provide a better service (cf. Baldwin & Clark, 2000). The apparent dependence on CDNs becomes another piece of the puzzle for a more effective distribution system that leverages competitive user experiences among audiences. This suggests that television content providers do not believe they lose autonomy when they outsource their distribution process, but rather that they never had that autonomy to begin with – because they are dependent on the technology that provides the best results at the moment. Their capacity to fulfil the universal service provision is more dependent on the technology itself and the fact that it runs smoothly, than who runs the process itself. CDNs expand the value chain and bring in a wider set of players in the distribution process, but in themselves, they do not seem to change the overall structure of the television production value chain. CDNs thus enter the value chain, displacing predominantly nationally owned and operated services provided in the DTT, satellite, fiber, and cable distribution systems for television delivery. While Norwegian-based actors such as Telenor provides CDN services as part of their national infrastructure, they cannot compete with global market leaders on scale, infrastructure, and know-how. Overall, this challenges the ideal of universalism as something that can indeed be safeguarded by state regulation (cf. Collins et al., 2001; Harrison & Wessels, 2005), as CDNs do not fall under the jurisdiction of current regulation. Furthermore, it challenges the future viability of tying PSM remits to universal service. This study thus contributes to value chain analyses of television distribution by illustrating how modularity can be modelled within the value chain, highlighting the importance of the connection that links the chains.

6. Conclusions

The question addressed in this study investigates what the outsourcing of distribution to CDNs means for television's universal service provision, the answer to which is twofold. First, CDNs are an inevitable link in on-demand digital content distribution. Thus, from an operational perspective, CDNs do not particularly change television's universal service provision as it stands. If anything, CDNs contribute to universal service, as they provide fast, outsourced content delivery. From the perspective of our informants, not outsourcing distribution to CDNs could render their service less competitive, which would curtail their universal service provision.

Second, television distribution in Norway is predominantly outsourced to foreign third-party providers. To our informants, this does not seem to be an issue, not least because modularity always allows them to shift to another, better provider. However, from a strategic perspective, the control over content and the sovereignty over how content is handled is diminished the moment that content leaves national borders. This is, of course, a potential sovereignty issue, but it clearly demonstrates the extent to which the regulatory power of the state to enforce media policy is diminished. As is the capacity of broadcasters to enforce their universal provision onto third-party providers, as CDNs are not subject to must-carry obligations.

The contribution of this study is thus to highlight how CDNs constitute key infrastructures in television delivery. While CDNs do not seem to make the value chain obsolete as a model for understanding television's ecosystem, this investigation has also revealed how vertical consolidation processes influence the mode of delivery in television streaming. To safeguard universalism in television delivery, definitions of what the technological infrastructures of communication actually are should be expanded to bring CDN technology under the provisions of broadcasting. As it is the state's responsibility to ensure the infrastructure for freedom of expression (see §100 of the Norwegian constitution), this responsibility presupposes that there is some measure of oversight or regulation on the part of authorities over this infrastructure, otherwise universality cannot be ensured. The current legal premises to ensure this infrastructure – the must-carry obligation as well as the licensed terrestrial transmission system – pertain to the cable and DTT infrastructures that fall under the Broadcasting Act. CDN delivery is involved in these transmission systems as efficiency and quality measures needed to ensure universal service. Bringing CDN services under universal service regulation would ensure must-carry obligations on par with the cable operators – a measure deemed necessary in the past to prevent unfair treatment of public service broadcasting by private actors operating public good services.

Further research should investigate how these consolidation processes shift power in the television ecosystem towards stronger dependencies. Comparative research would also provide further insight into distribution strategies across media systems. Case studies of in-house CDN strategies would moreover help to shed light on how scale influences autonomy and the role of data in securing competitive advantage in the global streaming economy.

7. Limitations

Like any study this one comes with limitations. While our informants represent key players in the television industries in Norway, our selection is not able to shed light on the CDN strategies or distribution value chains of regional and global streaming actors such as HBO, Viaplay or Discovery, who also operate within this market. Nor does our research include broadcasters with in-house CDN solutions, such as SVT in Sweden or the BBC in the UK. An inherent limitation to enquiries of this kind is that access to industry players is difficult, as strategies are proprietary and markets are competitive. Our study is also not granular enough to offer insight into the different streaming technologies applied across broadcasters. Finally, developments in the communication infrastructure are fast-paced and the ecosystem changes rapidly. Research of this kind can thus provide little more than a snapshot of developments.

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CRediT authorship contribution statement

Helle Sjøvaag: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. **Ragnhild Kr. Olsen:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Raul Ferrer-Conill:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Visualization, Writing – original draft, Writing – review & editing.

References

Baldwin, C. Y., & Clark, K. B. (2000). *Design rules: The power of modularity*. MIT press.
Benghozi, P. J., & Simon, J. P. (2016). Out of the Blue: The rise of CDN networks. *Digiworld Economic Journal, 101*(1), 107–128.
Benson, R., Neff, T., & Hessérus, M. (2018). Media ownership and public service news: How strong are institutional logics? *The International Journal of Press/Politics, 23*(3), 275–298.
Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77–101.
Chalaby, J. K. (2016). Television and globalization: The TV content global value chain. *Journal of Communication, 66*(1), 35–59.
Chalaby, J. K. (2017). Can a GVC-oriented policy mitigate the inequalities of the world media system? Strategies for economic upgrading in the TV format global value chain. *International Journal of Digital Television, 8*(1), 9–28.
Chalaby, J. K., & Plunkett, S. (2021). Standing on the shoulders of tech giants: Media delivery, streaming television and the rise of global suppliers. *New Media & Society, 23*(11), 3206–3228.
Chan-Olmsted, S. M. (2019). A review of artificial intelligence adoptions in the media industry. *International Journal on Media Management, 21*(3–4), 193–215.
Collins, R., Finn, A., McFadyen, S., & Hoskins, C. (2001). Public service broadcasting beyond 2000: Is there a future for public service broadcasting? *Canadian Journal of Communication, 26*(1), 3–16.
Constantinides, P., Henfridsson, O., & Parker, G. G. (2018). Introduction: Platforms and infrastructures in the digital age. *Information Systems Research, 29*(2), 381–400.
Doyle, G. (2016). Resistance of channels: Television distribution in the multiplatform era. *Telematics and Informatics, 33*(2), 693–702.
Doyle, G. (2018). Television and the development of the data economy: Data analysis, power and the public interest. *International Journal of Digital Television, 9*(1), 53–68.
EBU. (2022). *CDN architectures demystified: An insight into CDN approaches employed by EBU Members*. EBU Broadband Distribution Architectures Group. https://tech.ebu.ch/publications/tr068. (Accessed 1 September 2023).
EC. (2018). *Special Eurobarometer 462: E-Communications and digital single market*. file:///Users/2917924/Downloads/bes_462_en.pdf . (Accessed 28 January 2024).
Ecom Act (Lov-2003-07-04-83) Lov om elektronisk kommunikasjon (ekomloven). [Law on electronic communication (the ecom act)].
Evens, T. (2010). Value networks and changing business models for the digital television industry. *Journal of media business studies, 7*(4), 41–58.
Evens, T., & Donders, K. (2018). *Platform power and policy in transforming television markets*. Palgrave.
Ferrer-Conill, R. (2016). Camouflaging church as state: An exploratory study of journalism's native advertising. *Journalism Studies, 17*(7), 904–914.
Fitzgerald, S. (2019). Over-the-top video services in India: Media imperialism after globalization. *Media Industries Journal, 6*(2), 89–116.
FOR-1997-02-28-153 Forskrift om kringkasting og audiovisuelle bestillingstjenester. [Regulation on broadasting and audiovisual servies].
Frischmann, B. M. (2012). *Infrastructure: The social value of shared resources*. Oxford University Press.
Ghaznavi, M., Jalalpour, E., Salahuddin, M. A., Boutaba, R., Migault, D., & Preda, S. (2021). Content delivery network security: A survey. *IEEE Communications Surveys & Tutorials, 23*(4), 2166–2190.
Gómez, R., & Munoz Larroa, A. (2023). Netflix in Mexico: An example of the tech Giant's Transnational business strategies. *Television & New Media, 24*(1), 88–105.
Government of Norway. (2023). *Avtale om levering av kommersielle allmennkringkastingstjenester. [Agreement on commercial public service broadcasting]*. https://www.regjeringen.no/contentassets/6645c8d28ddb4b1eb85ef97f698af549/avtale-av-26.-september-2018-mellom-staten-ved-kulturdepartementet-og-tv-2-as-.pdf. (Accessed 1 September 2023).
Hadida, A. L., Lampel, J., Walls, W. D., & Joshi, A. (2021). Hollywood studio filmmaking in the age of Netflix: A tale of two institutional logics. *Journal of Cultural Economics, 45*, 213–238.
Harrison, J., & Wessels, B. (2005). A new public service communication environment? Public service broadcasting values in the reconfiguring media. *New Media & Society, 7*(6), 834–853.
Hesmondhalgh, D. (2006). Bourdieu, the media and cultural production. *Media, Culture & Society, 28*(2), 211–231.
Hesmondhalgh, D., Valverde, R. C., Kaye, D. B. V., & Li, Z. (2023). Digital platforms and infrastructure in the realm of culture. *Media and Communication, 11*(2), 296–306.

Johnson, C. (2021). The online television industry: Fragmentation, consolidation, and power. In P. McDonald (Ed.), *The Routledge companion to media industries* (pp. 237–246). Routledge.
Just, N. (2022). Which is to Be Master? Competition Law or regulation in platform markets. *International Journal of Communication*, (16), 504–524.
Khalil, J. F., & Zayani, M. (2022). Digitality and debordered spaces in the era of streaming: A global South perspective. *Television & New Media, 23*(2), 167–183.
Li, X., Darwich, M., Salehi, M. A., & Bayoumi, M. (2021). A survey on cloud-based video streaming services. *Advances in Computers, 123*, 194–244.
Lievrouw, L. A. (2000). The information environment and universal service. *The Information Society, 16*(2), 155–159.
Lotz, A., Lobato, R., & Thomas, J. (2018). Internet-distributed television research: A provocation. *Media Industries, 5*(2), 1–13.
Lov om kringkasting og audiovisuelle bestillingstjenester (kringkastingsloven). [Law on broadcasting and audiovisual services. The Broadcasting Act].
Martin, E. N. (2021). Can public service broadcasting survive Silicon valley? Synthesizing leadership perspectives at the BBC, PBS, NPR, CPB and local US stations. *Technology in Society, 64*, Article 101451.
McAllister, M. P., & Proffitt, J. M. (2020). Media ownership, autonomy, and democracy in a corporate age. In L. Wilkins, & C. G. Christians (Eds.), *The Routledge Handbook of Mass media ethics (465-478)*. Routledge.
Meese, J. (2020). Telecommunications companies as digital broadcasters: The importance of net neutrality in competitive markets. *Television & New Media, 21*(5), 530–546.
Meld, S. T. (2020-2021). *Vår felles digitale grunnmur: Mobil, bredbånds- og internettjenester [Our common digital infrastructure: Mobile, broadband and internet services], 28*. Ministry of Local Government and Regional Development.
Mikos, L. (2016). Digital media platforms and the use of TV content: Binge watching and video-on-demand in Germany. *Media and Communication, 4*(3), 154–161.
Musiani, F. (2022). Infrastructuring digital sovereignty: A research agenda for an infrastructure-based sociology of digital self-determination practices. *Information, Communication & Society, 25*(6), 785–800.
Narayan, D. (2022). Platform capitalism and cloud infrastructure: Theorizing a hyper-scalable computing regime. *Environment and Planning A: Economy and Space, 54*(5), 911–929.
Nikunen, K., & Hokka, J. (2020). Welfare state values and public service media in the era of datafication. *Global Perspectives, 1*(1), Article 12906.
Nkom. (2020). Telecommunications markets in the Nordic and Baltic countries 2019. *The Norwegian Communications Authority*. https://nkom.no/aktuelt/norge-p%C3%A5-topp-i-norden-i-antall-private-abonnement-med-fast-bredb%C3%A5nd. (Accessed 10 January 2024).
Nkom. (2023). Ekomstatistikk [Ecom Statistics]. *The Norwegian Communications Authority*. https://nkom.no/statistikk/nokkeltall-og-interaktive-dashbord/ekomstatistikk. (Accessed 10 January 2024).
Noam, E. M. (1997). *Will universal service and Common carriage survive the telecommunications act of 1996?* Columbia Law Review.
NRK. (2023). Bylaws for NRK AS. https://info.nrk.no/vedtekter/. (Accessed 10 January 2024).
Ofcom. (2023). Future of TV distribution. *Call for evidence*. https://www.ofcom.org.uk/_data/assets/pdf_file/0038/269777/Call-for-Evidence-Future-of-TV-Distribution.pdf. (Accessed 10 January 2024).
Paul, S. (2011). *Digital video distribution in broadband, television, mobile and converged networks: Trends, challenges and solutions*. John Wiley & Sons.
Phillippi, J., & Lauderdale, J. (2018). A guide to field notes for qualitative research: Context and conversation. *Qualitative Health Research, 28*(3), 381–388.
Porter, M. E. (1985). *Competitive advantage: Creating and sustaining superior performance*. Free Press.
Prario, B. (2007). Mobile television in Italy: Value chains and business models of telecommunications operators. *Journal of Media Business Studies, 4*(1), 1–19.
Ramasoota, P., & Kitikamdhorn, A. (2021). "The Netflix effect" in Thailand: Industry and regulatory implications. *Telecommunications Policy, 45*(7), Article 102156.
Simpson, S. (2004). Universal service issues in converging communications environments: The case of the UK. *Telecommunications Policy, 28*(3–4), 233–248.
Sørensen, J. K. (2020). The datafication of public service media dreams, dilemmas and practical problems: A case study of the implementation of personalized recommendations at the Danish public service media 'DR'. *MedieKultur: Journal of media and communication research, 36*(69), 90–115.
Stocker, V., Smaragdakis, G., Lehr, W., & 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., & Whalley, J. (2018). Speed isn't everything: A multi-criteria analysis of the broadband consumer experience in the UK. *Telecommunications Policy, 42*(1), 1–14.
Storsul, T. (2008). Bakkenettet og allmennkringkastinga. *Norsk medietidsskrift, 15*(1), 38–56.
Strangelove, M. (2015). *Post-TV: Piracy, cord-cutting, and the future of television*. University of Toronto Press.
Tay, J., & Turner, G. (2008). What is television? Comparing media systems in the post-broadcast era. *Media International Australia, 126*(1), 71–81.
Turner, G. (2009). Television and the nation: Does this matter any more?.". In G. Turner, & G. Tay (Eds.), *Television Studies after TV (64-74)*. Routledge.
TV 2. (2023). Vedtak om tildeling av avtale om kommersiell allmennkringkasting til TV 2 AS. [Decision on agrement on commercial public service broadcasting status to TV 2 AS]. https://www.regjeringen.no/contentassets/085f3b023ea3450da0ec2730571cefff/vedtak-om-tildeling-av-avtale-om-kommersiell-allmennkringkasting-til-tv-2-as-l2281971.pdf.
Uricchio, W. (2009). The future of a medium once known as television. In P. Snickars, & P. Vonderau (Eds.), *The YouTube Reader* (pp. 24–39). Wallflower Press.
Van Es, K., & Poell, T. (2020). Platform imaginaries and Dutch public service media. *Social Media+ Society, 6*(2), Article 2056305120933289.
Van Esler, M. (2016). Not yet the post-TV era: Network and MVPD adaptation to emergent distribution technologies. *Media and Communication, 4*(3), 131–141.
Verhoest, P. (2000). The myth of universal service: Hermeneutic considerations and political recommendations. *Media, Culture & Society, 22*(5), 595–610.
Williams, P. (2020). The 'collaborative personal Statement': A more inclusive method of data-gathering than audio recording interviews with vulnerable people. *European Journal of Special Needs Education, 35*(4), 466–481.
Yin, F., Pan, Y., & Guo, X. (2020). Smart television edge server Deployment Scheme based on CDN. In *2020 12th International Conference on Advanced Infocomm technology (ICAIT)* (pp. 58–63). IEEE. November.
Sjøvaag, H., & Ferrer-Conill, R. (2024). Digital communication infrastructures and the principle of universality: Challanges for Nordic media welfare state jurisdictions. In P. Jakobsson, & F. Stiernstedt (Eds.), *The future of the Nordic media model: A digital media welfare state?* Nordicom.

Helle Sjøvaag is Professor of Journalism at the University of Stavanger, Norway. Her research focuses on media economics, digital infrastructures, datafication and regulation of the communication industries. She currently leads the RCN-funded project *The datafication of communicative power: Towards an independent media policy for Norway's digital infrastructures*. Her most recent book is *The markets for news: Enduring structures in the age of business model disruptions* (Routledge, 2023).

Ragnhild Kr. Olsen is an Associate Professor at the Department of Journalism and Media Studies at Oslo Metropolitan University. Her research interests are digitisation and value creation in journalism, particularly in local journalism, as well as media innovation, audience perspectives in editorial priorities, and platformisation of news media.

Raul Ferrer-Conill is Professor of journalism in the Department of Media and Social Sciences at the University of Stavanger, Norway. His research focuses on digital journalism, media engagement, and sociotechnical processes of datafication. He currently leads the Digital Society Research Group and is chair of the Journalism Studies Division of Nordmedia. Ferrer-Conill received the Bob Franklin Journal Article Award in 2021.