Comparing Digital Communication Systems

An empirical framework for analysing the political economy of digital infrastructures

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Abstract

This article offers a research tool for comparative studies of digital communication systems. It brings together the fields of infrastructure studies, Internet governance, and political economy of the Internet with the tradition of systemic media analysis and argues that existing frameworks are inadequate for capturing regulatory and power structures in a complex digital environment. In the article, we develop a framework for conceptualising and mapping the components of digital communication systems – the DCS framework – and operationalise it for standardised measurements by outlining twelve key indicators that can be analysed using empirical data from a number of existing databases. The framework provides a basis for measuring and comparing digital communication systems across national or regional contexts, and thereby developing new typologies for how to understand structural differences and similarities.

Keywords: digital communication system, infrastructure, media system analysis, Internet governance, political economy

Introduction

Since the general diffusion of the Internet from the early 1990s, the structural conditions that frame people's communication have changed radically alongside the emergence of new technologies, market actors, and types of governance. Especially the dominant position of what is popularly referred to as the FAANG enterprises (Facebook, Apple, Amazon, Netflix, and Google) and the regulatory challenges related to these have attracted growing scholarly attention in recent years. Digital power structures and control mechanisms are now at the top of the research agenda in the fields of Internet governance and political economy of communication (see, e.g., Musiani et al., 2016; Winseck, 2019; Zuboff, 2019). Research in these fields usually consists of case studies of particular companies, sectors, or business models, or it focuses on specific governance processes. A

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critical next step is to apply a broader, macro perspective that enables the development of typologies for making sense of and distinguishing between structural developments and conditions across different geopolitical contexts.

In this article, we provide a framework for empirically analysing and comparing digital communication systems – the DCS framework. The framework is inspired by the tradition of media systems analysis (Blumler & Gurevitch, 1975; Hallin & Mancini, 2004; Siebert et al., 1956) in studying how the structural conditions for communication differ across societal contexts and focusing on the mutual impact of state regulation and market dynamics. However, it also answers persistent calls (see Curran, 2011; Hardy, 2012; Mattoni & Ceccobelli, 2018; Norris, 2009) for systematic analyses that "go beyond the narrow realm of traditional news production" (Brüggemann et al., 2014: 1038) characteristic of Hallin and Mancini's (2004) landmark study of media systems. The DCS framework thereby contributes to understanding and researching the still emergent digital power structures and governance forms by developing and qualifying the theoretical, methodological, and empirical approaches to researching the questions that media system scholars have asked for decades.

While a strengthened attention towards digital infrastructures and away from historical institutions (such as the press) is long overdue in the field of systemic media studies, a holistic and macro-oriented approach to studying digital power structures and regulation is timely for contemporary Internet studies. Building on earlier work conceptualising and mapping the components of digital communication systems (Flensburg & Lai, 2019), we develop indicators and measures for comparing different societal contexts, which have been tested in a comparison of different periods in the history of the Internet (Flensburg & Lai, 2020). In doing so, this article meets the challenge of operationalising the theoretical definition of a digital communication system into an empirical framework for measuring and comparing how Internet-based communication is conditioned and structured. We thereby address the following research question:

- What are the appropriate indicators for comparing digital communication systems, and how can they be measured using standardised data?

We first elaborate on and discuss how the fields of Internet governance, digital infrastructure studies, and political economy of (digital) communication can benefit from the tradition of media system analyses – and how media system analyses, in turn, have neglected to address the fundamental challenges related to digitalisation. This leads us to a three-step exploration of how to 1) define and conceptualise digital communication systems as objects of analysis; 2) operationalise the concept of digital communication systems through the development of analytical dimensions and variables; and 3) develop indicators and measures for conducting empirical analyses and comparisons of structural differences across digital communication systems. In the concluding section, we discuss the main advantages, challenges, and limitations of the framework and outline the future prospects of comparative digital communication system analysis.

State of the art

The political economy and governance of digital infrastructures

This research is placed at the intersection between three already-entangled research fields: Internet governance, infrastructure studies, and political economy of (digital) communication. Studies of Internet governance identify and analyse emerging power formations and control mechanisms and stress the need to move beyond established and official government structures (DeNardis, 2012). Studies in this vein usually focus on isolating and categorising the multitude of stakeholders involved in Internet governance processes, the arenas where digital power is negotiated, as well as the different settings, arrangements, and processes that frame the development of the Internet and with it, digital communication (see, e.g., Badouard et al., 2013; Fung, 2006; Rosnay & Musiani, 2016). Acknowledging that power is increasingly exercised *through* as well as *by* technological systems (Musiani et al., 2016), Internet governance studies have in recent years turned to studying infrastructures as central focal points.

Internet governance research is thereby increasingly moving towards the growing field of Internet infrastructure studies, which emphasise the material aspects of digital communication – that is "the Internet not as 'what people say with it' but as 'how it works'" (Sandvig, 2013: 90). Studies within this broad and loosely assembled field generally explore how digital technologies are developed, implemented, and maintained, often through sociotechnical analyses of actor-network relationships. While many studies adopt a social constructivist perspective – seeing infrastructure as a "fundamentally relational concept" (Bowker et al., 2009: 99) that can only be studied when in use and thereby through (case) studies of particular processes – a more materialist fraction of the field conceptualises infrastructures in a somewhat conventional way as physical resources that enable (and constrain) critical societal functions (Frischmann, 2012). The following conceptualisation of digital communication systems follows this materialist approach and defines infrastructures as physical resources that can be built, owned, supplied, used, and thus regulated.

This materialist approach is closely related to research within the field of political economy. The understanding of infrastructures as material resources that are both valuable and critical – and, as such, subject to both political and economic power struggles – motivates research to engage in analyses of ownership structures, business models, and regulatory arrangements that organise the distribution and control of "the internet [infrastructure] as one of today's most important forms of world property" (Mazepa & Mosco, 2016: 163). Applying a political economy perspective to Internet governance thereby entails studying macro structures rather than micro processes surrounding digital infrastructures. In other words, not so much studying how control is exercised through particular activities or interactions, but rather how the *ability* to exercise control is established, maintained, and intensified through institutionalisation of societal power and control (Mansell, 2017).

A recent example that illustrates the need for and increasing interest in studying and comparing Internet governance from a macroscopic political economy perspective can be found in O'Hara and Hall's (2018) paper, Four Internets, in which the authors distinguish between open, bourgeois, authoritarian, and commercial Internets and suggest that these different regimes can be found in, respectively, the US as represented by Silicon Valley,

the EU as represented by Brussels, China as represented by Beijing, and another version of the US as represented by Washington DC. These rather tentative categorisations are based on a number of examples of how the Internet is regulated in different geopolitical contexts and call for more systematic developments of theoretical, methodological, and empirical frameworks that can serve as a basis for confirming, correcting, or falsifying such emergent typologies of Internet regimes – or for identifying new ones altogether. In order to do so, in the following section we suggest that Internet studies should seek inspiration in the tradition of media system analysis.

Media system analysis

Since the publication of *Four Theories of the Press* (Siebert et al., 1956), media and communication researchers have developed and applied typologies that can explain the role of legacy media institutions across regions. Especially, the models published in *Comparing Media Systems* (Hallin & Mancini, 2004) – and specified by Brüggemann and colleagues (2014) – have formed the basis for numerous empirical analyses of the power structures and regulatory mechanisms in different contexts. Journalism and news studies, in particular, have gained valuable insights from using the models for explaining more specific communication practices and outputs in and across national settings, and Hallin and Mancini's analytical framework and its typologies continue to dominate structural and comparative studies in the media and communication field. It also serves as a recurrent reference for studies of digitalised media environments that continue to refer to the liberal, polarised pluralist, and democratic corporatist models when explaining structural differences across geopolitical contexts (see, e.g., Büchel et al., 2016; Flew & Waisbord, 2015; Herrero et al., 2017; Ohlsson, 2015; Psychogiopoulou, 2014).

Following the widespread use of their framework, Hallin and Mancini (2012: 207) have raised concerns about pushing it "beyond what it can reasonably be expected to do", and various researchers have criticised its narrow focus on news media and newspapers. Norris (2009: 332), for instance, notes that "the 800-pound gorilla in the room, concerns the role of new information and telecommunication, which are not featured anywhere as part of the classification". Furthermore, in their development of Hallin and Mancini's framework, Brüggemann and colleagues (2014: 1062 & 1038) acknowledge that the "major challenge for research [is] going beyond Hallin and Mancini (2004) rather than only revisiting it" and that the "future study of media systems should indeed include new forms of digital communication". A limited number of studies have addressed this call by, for instance, adding indicators on Internet and communication technologies to the existing indicators on news production (Mattoni & Ceccobelli, 2018). Yet, despite the general acknowledgement of the limitations, no alternatives have been developed for empirically assessing and comparing the digital environments that shape communication in a broader sense. That is, although frameworks and typologies focusing on particular aspects of digital communication have been developed, they do not address the digital communication system at large, nor do they offer empirical indicators and measures for making comparisons across contexts. In effect, Hallin and Mancini's analytical dimensions, empirical measures, as well as the typologies identified on the basis of these, stand relatively alone and uncontested.

The continued use of the media system framework, on the one hand, clearly testifies to a persistent need and demand for empirical and macro-oriented approaches that can explain the complex ways society influences communication media and vice versa. On the other hand, the lack of more up-to-date frameworks, which include digital media, indicates that we are still in the early stages of developing models for assessing how digital communication is structured within different societal settings. The remainder of the article contributes to this emergent research effort by leaving behind the indicators and measures suggested by Hallin and Mancini, but sustaining the basic research interest of the media system tradition. The DCS framework, similar to the media system approach, thus addresses questions of how communication is organised and controlled but does so on the basis of an entirely different conception of what the system is.

Step one: Digital communication systems

Following the critique of news- and journalism-centric media system analyses, we argue in favour of broader communication system analyses that entail a re-evaluation of the components of the systems supporting and framing mediated communications. In line with the "turn to infrastructure in internet governance" (Musiani et al., 2016), we suggest a move away from focusing on particular types of mediated content (e.g., news) and towards increased attention to the technological systems supporting the distribution of digitally mediated communication in general. This also entails challenging the assumption that the press, or other legacy media institutions, play an a priori role in people's communication and make up an independent system. In other words, rather than focusing on the structural conditions of particular institutions or sectors (e.g., broadcasters, social media platforms, etc.), we approach the questions of how Internet-based communication is controlled and regulated in different societal contexts more openly.

This re-conceptualisation follows Lessig's (2006: 121) call for "a more general understanding of how regulation works – one that focuses on more than the single influence of any one force such as government, norms, or the market, and instead integrates these factors into a single account". By taking a step back and reconsidering the structural conditions that frame digital communication – irrespective of historically defined sectors and official policy schemes – we can explore alternative analytical approaches to studying the structural forces that shape and condition digital communication. In line with Lessig's work, media system analyses, and the political economy tradition, we pay particular attention to media markets, competition structures, and political regulation as important dimensions for understanding the structural conditions that shape digital communication. But while especially media system analyses tend to treat infrastructures and technologies as implicit conditions, rather than analytical dimensions in their own right (Hallin & Mancini, 2004), we recast the material resources that support digital communication as a fundamental dimension interacting with and impacting the development of both economic and political structures in important ways. That is, we see infrastructural resources as basic material foundations for establishing digital business models and for initiating and exercising political regulation of digital systems – and thereby as a valuable starting point for identifying the most powerful market players as well as the impact of policies and state regulation.

Our conceptualisation of a digital communication system thereby consists of three dimensions: infrastructure, market, and role of the state. The infrastructure dimension refers to the material resources that support any Internet-based activity (e.g., devices, network connections, servers, software, data streams, etc.). The market dimension includes market actors, business models, and competition structures that own, supply, and control these resources. The role of the state dimension covers the ways state authorities intervene and shape the ways infrastructural resources are organised and distributed through, for instance, market regulation. We acknowledge that cultural factors impact the use of digital communication media and thereby the development of infrastructures, market norms and business strategies, as well as ideological principles shaping policy processes and regulatory practices. However, cultural norms and traditions do not figure as explicit dimensions, indicators, and measures in the framework, but are instead, we argue, important aspects that should be considered when interpreting and explaining differences and similarities that can be identified through analyses based on the proposed analytical framework.

Compared to the existing media system framework, this change of perspective raises new methodological challenges. It implies a tremendous extension of the scope of analysis by opening it up to an ever-growing mass of market players and governance forms that cut across the historic boundaries between sectors, policy frameworks, and research fields. This is, nonetheless, a necessary evil as the Internet is, and has been for some time, eroding these exact boundaries.

The DCS framework: Layers and dimensions

As described above, digital communication systems are analysed by first identifying the key material infrastructural resources underlying digital communication, and *then* assessing the market actors that own and control them, as well as the policies that regulate them. A crucial part of the development of the DCS framework is thereby to set out a strategy for identifying the most important components that make up the Internet infrastructure. As illustrated by, for instance, the widely used OSI model and TCP/IP protocol stack, the Internet consists of various layers that together enable data to flow between multiple devices, disparate networks, and different applications. These layers are hierarchical insofar as they refer to infrastructures that are activated following a certain chronology: in order to use the Internet for any type of communicative purpose, a user needs some sort of digital device (e.g., a smartphone) that is connected to an access network (e.g., a mobile broadband connection); this local network, in turn, requires access to the global Internet backbone (consisting of fibre-optic submarine cables, network hubs, etc.) that enable networks to exchange data; users furthermore must have access to software applications that turn raw data into readable content (e.g., video, text, sound, etc.); and finally, data and content must be produced and available, if the Internet is to be used for any of its multiple purposes.

On the basis of this walkthrough of the Internet infrastructure, we translate the theoretical conceptualisation of digital communication systems into an analytical matrix consisting of three dimensions and four layers, as overviewed in Table 1. Whereas the three dimensions refer to forces that structure digital communication – infrastructures, markets, and roles of the state – the analytical layers cover four basic material aspects

of digital communication: Internet-enabled devices and access networks; underlying backbone networks that connect local access networks; applications used for digital communication purposes; and digital communication content.

Table 1. *The digital communication system analytical matrix*

	Infrastructure	Market	Role of the state
Device and access networks	What are the existing devices and access networks for digital communication?	Who owns and controls devices and access networks?	How does the state regulate devices and access networks?
Backbone networks	What are the existing backbone networks for digital communication?	Who owns and controls backbone networks?	How does the state regulate backbone networks?
Applications	What are the existing applications for digital communication?	Who owns and controls digital communication applications?	How does the state regulate communication applications?
Content	What are existing types of digital communication content?	Who owns and controls digital communication content?	How does the state regulate communication content?

Source: Adapted from Flensburg & Lai, 2019: 697

The four analytical layers are interdependent insofar as devices as well as access networks are fundamental conditions enabling (or constraining) the dimensions following them. If, for instance, my DSL broadband connection is lost, I lose connection to the global backbone network of fibre cables and exchange points, which restricts my access to applications such as YouTube and to whatever content is there. As such, the analytical strategy is to start from the device and access network layer and from the infrastructural dimension, which, taken together, make up the upper left field in Table 1. By identifying the availability and use of, for instance, different digital devices and access networks, we can identify the most prominent market actors as well as the competition structures in the device manufacturer and telecommunications sectors, as well as the existing legislative frameworks or government interventions regulating the organisation of these infrastructures.

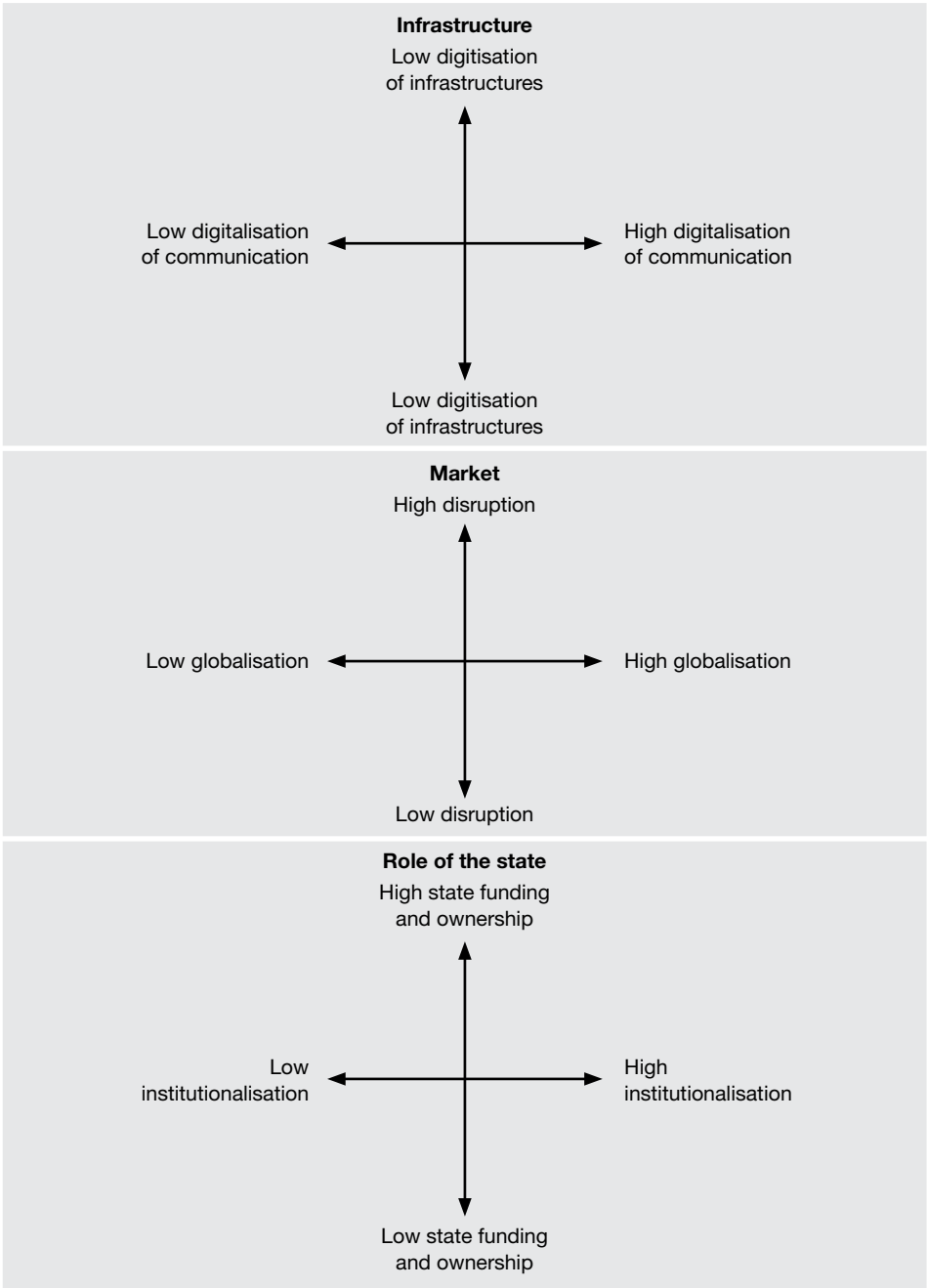
The matrix thereby serves as a mapping tool for identifying the components of digital communication systems, and as a basis for the further development of indicators and measures for comparing them. In order to operationalise the framework for comparative analyses, the next section specifies the analytical dimensions used for comparing digital communication systems in different contexts. We thereby break down the overall research question of how to compare digital communication systems into the following sub-questions: how can 1) the infrastructural conditions, 2) the market conditions, and 3) the role of the state be measured and compared when it comes to Internet-based communication in different national settings?

Step two: Operationalising the DCS framework

In order to characterise and compare different digital communication systems according to the three dimensions of the DCS framework (infrastructure, market, and role of the state), we divide each dimension into two subdimensions varying on a scale from

low to high, as visualised in Figure 1. This follows the strategy of Brüggemann and colleagues (2014: 1039), who argue that for any standardised measurement of media systems, "dimensions have to vary on a continuum between two poles".

Figure 1. *Subdimensions of the DCS framework*



In order to measure and compare the infrastructural conditions across national settings, we focus on the development of digital infrastructures and the reliance on them for communicating across different domains of life. We label the infrastructure subdimensions digitisation of infrastructures and digitalisation of communication. Digitisation refers, in this context, to the material process whereby analogue information is converted into digital bits, whereas digitalisation refers to the restructuring of many aspects of social life around digital communication (Brennen & Kreiss, 2016). The subdimensions are mutually dependent: the degree of digitisation of communication infrastructures (based on, e.g., the availability of digital devices and access network, the build-out of the backbone, the access to various applications as well as digital content) forms the basis for how the Internet can be used for communicative purposes in a given context. Similarly, the degree of digitalisation of social life and mundane communication (the extent to which various technologies and services are used) is not only dependent on the existing digital infrastructures but also pushes further infrastructural developments.

The market conditions are similarly measured by assessing the degree to which the digital communication market is controlled by digitally native or legacy corporations and by national or international market actors. The market dimension is thereby divided into the subdimensions of disruption and globalisation. The first distinguishes between brownfield and greenfield market actors and business models (Hjarvard & Helles, 2015) and refers to the power balance between them. Greenfield actors are understood as the new digital entrants (companies such as Google, Facebook, etc., that were born side by side with the Internet), while brownfield actors refer to incumbent, legacy players (existing corporations such as telephone companies, news media, etc., that had established market positions long before the Internet became common property). The latter subdimension, in turn, refers to the level of globalisation of the market as opposed to more nationalised markets. Both subdimensions derive from buzzwords in current market discourse, as they address the restructuring of historical power structures and control mechanisms represented by national market actors and legacy business models.

Lastly, the role of the state dimension is measured by evaluating the extent to which the state is actively involved in the development of digital infrastructures and markets, and the existence of formalised policies and official agencies regulating digital communication specifically. We thereby distinguish between levels of state funding and ownership, and institutionalisation. The two subdimensions do not cover the entirety of ways the state regulates digital communication, yet they represent two significant types of state involvement: one is subject to a continuous research interest in funding and ownership in media systems and political economy studies; the other follows the tradition of media and communication policy studies to focus on formalised state regulation, even as this perspective omits other types of governance (Haenens et al., 2018).

In order to characterise and compare different digital communication systems, we use the twelve indicative questions outlined in the matrix in Table 1 and translate them into more specific indicators and measures targeted at the three dimensions and six subdimensions of Figure 1. In other words, the four analytical layers (devices and access networks, backbone networks, applications, and content) of the DCS framework form the outset for developing relevant and specific indicators and measures for analysing the dimensions of infrastructure, market, and role of the state. The following section points to the various data sources that can be used to empirically analyse and compare

digital communication systems and describes the operationalisation of the analytical dimensions in detail.

Step three: Indicators and measures for comparing digital communication systems

The dimensions of the analytical framework presented above can all investigated using publicly available data, as overviewed in Table 2. The datasets suggested for future digital communication system analyses differ in terms of data source, population, and sample. They are all up to date, go at least ten years back in time, and can be compared across the European Union countries, while additional sources must be added for global comparisons. The sources use a multitude of methods such as surveys and panels, web traffic measurements, registry data, and industry reports, which can also be found in Table 2. For the infrastructure and role of the state dimensions, the data is more or less readily available, whereas the market dimension requires significant data transformations in the form of coding following a coding manual, which will be elaborated on shortly.

Table 2. *Data sources*

Data Source	Time period	Collection method	Population	Sample
Amazon Alexa Top Sites (AA)	2009–2020	web panels and cookie data	national population	not available
Official Domain Name Administrator (ODNA) Statistics [who-is database]	1997–2020	registry of national domain names	national domain names	census
Eurostat (ES)	1990–2020	online survey (collected by the National Statistical Institute)	individuals aged 16+; households	1500*
International Telecommunications Union (ITU)	2000–2020	National Telecommunication Statistics reporting	national population	census
Internet Archive Wayback Machine (IAWM)	1996–2020	archiving of websites	World Wide Web	330 billion web pages
Regional Internet Registers (RIR) Statistics – RIPE NCC Allocations	1970–2020	Registry of Autonomous System Number (ASN) requests	ASNs	census
Statcounter Global Stats (SCGS)	2009–2020	cookie data	national population	2 million websites
TeleGeography Internet Exchange Map (TIEM)	1989–2020	industry participants survey (cable owners, carriers) augmented with publicly available information (e.g., FCC cable landing licenses)	submarine cables worldwide	census
TeleGeography Submarine Cable Map (TSCM)	1989–2020	industry participants survey (IXP owners) augmented with publicly available information	IXPs worldwide	census
National Telecommunication Statistics (NTS)	2000–2020	industry participants reporting	broadband connections nationwide	census

* Standard sample size for the national statistical agency

Infrastructures

For the infrastructure dimension, the four indicators, identical to the four layers of digital communication in the DSC framework (Table 1), can be analysed and compared using the measures outlined in Table 3.

Table 3. *Operationalisation of the infrastructure dimension (subdimensions: digitisation of infrastructures and digitalisation of communication)*

Indicator	Measure	Data transformation	Source
Device and access networks	Internet penetration, households (%)	–	ES
	Smartphone ownership, households (%)	–	ES
	PC ownership, households (%)	–	ES
	Fixed line broadband subscriptions (per 100 inhabitants)	–	ITU (NTS)
	Mobile broadband subscriptions (per 100 inhabitants)	–	ITU (NTS)
Backbone networks	Cable landings in country (per 10 million inhabitants)	collection & accumulation of cable landings	TG
	Kilometres of submarine cables landing in country (per 10 million inhabitants)	collection & accumulation of cable lengths	TG
	IXPs (per 10 million inhabitants)	collection & accumulation of IXPs	TG
	ASNs (per 10 million inhabitants)	collection & accumulation of ASNs	RIR (RIPE NCC)
Applications	Website categories in top 100 (%)	coding of websites according to activity categories (see measures of content indicator)	AA* (IAWM)
	National domain names (%)	–	ODNA & ILS
Content	Internet activities – use in the last three months (%): news; music, videos, games; VoD; video calls; social networks; banking; shopping; interaction with public authorities (last 12 months)	–	ES

* "The monthly rank is calculated using a combination of average daily visitors and pageviews over the past month. The site with the highest combination of visitors and pageviews is ranked #1" (Alexa, n.d.).

Table 3 shows how we, for device and access networks, focus on the diffusion of smartphones, PCs, and Internet connections in households, as well as the number of fixed-line and mobile broadband subscriptions per 100 inhabitants. These measures reflect the standardised ways that, for instance, the European Union and OECD determine the degree of digitisation and general Internet and communication technology development. We distinguish between wired and mobile networks in order to emphasise the different material conditions for communicating digitally – features that, in turn, frame and impact market conditions as well as regulatory scopes for action (e.g., wired broadband connections are typically supplied on commercial terms, while mobile broadband is based on electromagnetic radio frequencies that are typically allocated by state authorities). The required data can be found in the Eurostat (ES) and the International Telecommunication Union (ITU) databases, both of which refer back

to national institutions and statistical bodies. The device and access network measures are mainly suited for determining the degree of digitisation of the infrastructure and less for assessing the use of digital communication services (i.e., the digitalisation of communication).

For the backbone network indicator, we develop four empirical measures adhering to existing research on key components of the Internet backbone (Winseck, 2019): the number of fibre optic submarine cable landings; the total length of the cables; the number of Internet exchange points (IXPs); and the number of assigned autonomous system numbers (ASNs). These measures focus on essential communication resources important for determining a particular societal context's degree of connectivity but also reflect often overlooked assets critical for obtaining power in the digital environment (e.g., powerful players such as Google and Facebook increasingly invest in backbone infrastructures in order to sustain and advance their business models and thereby cement and intensify their position across the value chain). The obtained data stem mainly from TeleGeography's (TG) resources and is, upon accumulation, normalised according to the population size. Similar to the measures for assessing device and access network penetration, these measures are mainly targeted at determining the degree of digitisation rather than digitalisation.

The application indicator is operationalised as a measure for determining the availability of digital communication services and for assessing the general adoption of them as an indicator for the degree of digitalisation across societal sectors and spheres of life. Despite the growing use of apps, which follows from the increase in smartphone use and mobile data, we focus on websites, since there is, to date, no Open Access comparative database overviewing app use (although, e.g., "App Annie" monitors the top downloaded apps, this does not relay accurate information about which is most used). In order to comparatively assess web usage, we rely on Amazon Alexa's (AA) Top Sites database, which, as of writing, is the default tool for global comparative web statistics. This dependence on commercial sources gives rise to a discussion – which by no means can be obtained in the space of this article – about the often-proprietary nature of digital data and the lack of official data sources. The top 100 websites in the Alexa database are coded according to the eight activity categories laid out in the content indicator in the next paragraph. Also, we use the measure of national domains relative to the size of the population in order to assess the prominence of applications accessible in the local language (Wresch, 2009). This last measure is based on official domain registries.

The content indicator contains measures of online activities and speaks to the subdimension of digitalisation of communication, or media use. The data stems from EuroStat (ES), and hence follows the standardised Digital Economy and Society Index (DESI), measuring the most prominent uses of Internet services: news; music, videos, and games; video-on-demand (VoD); video calls; social networks; banking; shopping; and interaction with public authorities. Focusing on this entire collection of digital activities and content types emphasises the comprehensive aim of the framework to not confine the analyses and typologies to one specific type of content but rather encompass the multitudes of ways the Internet supports vastly different communication purposes. In turn, on the one hand, the use of different types of content can be seen as a result of the infrastructural development (in order for people to, e.g., stream services, they need high-capacity broadband connections). On the other hand, an increasing use of different

types of digital services and content can explain a need for infrastructural build-outs and investments (thereby generating an increasing demand, and a market, for developing ever-more advanced infrastructures to sustain, e.g., the Internet of Things, facial recognition, etc.).

Markets

The indicators in the market dimension follow the infrastructure indicators insofar as they refer to the device and access network market, the application market, and so forth (see Table 4). For each indicator, measures of market shares (e.g., mobile broadband market shares, fibre-optic submarine cable market shares, top-sites market shares, etc.) are based on first a coding of market actors and then calculations of market shares. The market actors are coded according to a coding manual that differentiates between institutional (private or state owned), geographical (international or national), and market (greenfield or brownfield) affiliations. These codes are directly applicable to the subdimensions of disruption and globalisation in the market dimension, as well as the aspect of state ownership pertaining to the role of the state dimension. The extensive data transformation underlying this dimension stresses the lack of data on the digital economy at large.

Table 4. *Operationalisation of the market dimension (subdimensions: globalisation and disruption)*

Indicator	Measure (%)	Source
Devices and access network market	Mobile vendor market shares	SCGS
	Fixed-line broadband market shares	ITU (NTS)
	Mobile broadband market shares	NTS
Backbone network market	Submarine cable market shares	TG
	IXP market shares	TG
	ASN market shares	RIR (RIPE NCC)
Application market	Top-50 websites market shares	AA
	Browser market shares	SCGS
	Operative systems market shares	SCGS
Content market	Third-party cookies in top-50 market shares	AA + WebXray

Comments: All market data were coded according to ownership (national/international, greenfield/brownfield, and public/private). The last code speaks to the state funding and ownership subdimension of the role of the state dimension, but the data transformation in terms of the coding of respectively public and private, as well as publicly and privately funded, market actors is carried out concurrently with the remaining coding of market actors in the market dimension.

Table 4 shows how the device and access network market indicator is measured by calculating the market shares of mobile vendors along with fixed-line and mobile broadband providers. Mobile vendor market shares are derived from the StatCounter GlobalStats (SCGS). The International Telecommunications Union (ITU), via the national telecommunication statistics (NTS), provides data on fixed-line and mobile broadband actors, which are in turn coded according to the principles in the coding manual described above. These measures allow for analyses that chart the ratio and interdependence between legacy (brownfield) actors and digital native (greenfield) corporations in the

digital marketplace.

The backbone network market indicator is measured by Internet exchange points (IXPs), fibre-optic submarine cables, and autonomous system number (ASN) market shares. The IXP market shares stem from desktop research consisting of collecting the respective owners of the national IXPs as they appear in the TeleGeography (TG) Internet exchange point map, and the subsequent coding of these actors. The same procedure is followed in terms of the cable landings in the specific national context. The prominence of different types of market actors is calculated according to both the number of landing stations as well as the length of the cables in question. Lastly, the autonomous system numbers (ASNs) are accessed through the regional Internet registries (RIR) database, and the actors obtaining the ASNs are coded following the manual. Similar to the previous indicator, the three backbone market measures thereby apply to the subdimension of disruption, but also, importantly, to the globalisation subdimension by distinguishing between different degrees of national ownership of an essentially global infrastructure.

For the application market indicator, we measure market shares of the top 100 websites, existing browsers, and operative systems. Each website on the top-100 list is coded according to its market affiliation, and scores are calculated based on the eight established activity categories laid out in the content indicator of the infrastructure dimension (social networks, VoD, banking, etc.). The coding of market shares for operative systems and browsers is based on data from the StatCounter GlobalStats (SCGS) database. From an economic as well as a cultural perspective, the distribution between both national and international, and legacy players and newcomers, are indicative of the degrees of globalisation and disruption in a given digital communication system. For instance, the prominence of social network sites such as Facebook and streaming services such as Netflix testify to the extent to which OTT services (over-the-top, or services that bypass traditional platforms to offer services directly on the Internet) replace previous communication technologies and market actors.

Given that the above indicator evaluates the market shares of different types of applications, and thereby digital content providers, the content market indicator is directed at the business model underlying large parts of the commercial web: advertising. As such, we extract the existing unique third-party cookies (Helles et al., 2020) placed on the top-100 websites and code their market shares according to the coding manual. At the risk of repeating a worn-out metaphor, data is indeed the new oil (Yonego, 2014) of the digital economy, and as such, it is essential for any comparison of digital communication systems to take into account the ways power is distributed and exerted at this final layer of the system. That is, just like backbone infrastructure investments and build-outs are essential to large digital corporations, so is the capacity to operate in and profit from the most prominent business model in the data economy – online advertising.

Role of the state

Like the market indicators, the indicators in the role of the state dimension refer back to the infrastructure indicators (e.g., state regulation of backbone networks, state regulation of content, etc.). Across the four indicators, measures relating to the institutionalisation and state funding and ownership subdimensions were developed by reviewing a number of existing databases (that touch) on political regulation of the Internet (e.g., The

Economist Intelligence Unit, 2020), and estimating which of these policies are most influential when it comes to regulating digital infrastructures. The next analytical step entails assessing whether or not the listed policies and political agencies in Table 5 exist in the particular national setting. The chosen measures are in line with a number of contemporary constructed baselines for evaluating political regulation of the Internet, such as the "principles for governments" in the Contract for the Web (World Wide Web Foundation, n.d.). Data for assessing the aspect of state ownership is derived from the coding of market actors as either private or state owned, which was described in the previous section.

Table 5. *Operationalisation of the role of the state dimension (subdimension: institutionalisation and state funding and ownership)*

Indicator	Measure	Source
State regulation of devices and access networks	State ownership of Internet service providers (%)	ITU (NTS)
	Broadband strategy (yes/no)	NLD
	5G strategy (yes/no)	NLD
	State funding for broadband build-out (yes/no)	NLD
	Telecommunications agency responsible for digital communications services (yes/no)	NLD
	State ownership of submarine cables, IXPs, and ASNs (%)	TG + RIPE NCC
State regulation of backbone networks	Routing and peering policy – net neutrality (yes/no)	NLD
	Cable landing licence policy (yes/no)	NLD
	State funding for cable laying and IXPs (yes/no)	NLD
	Cyber security agency (yes/no)	NLD
	State ownership of websites, operative systems, and browsers (%)	AA + SCGS
State regulation of applications	Digitalisation agency (yes/no)	NLD
	Domain-name policy (yes/no)	NLD
	Digital public service funding (yes/no)	NLD
	Government e-inclusion strategy (yes/no)	NLD
	State ownership of third-party cookies (%)	WebXray
State regulation of content	State funding for digital content (yes/no)	NLD
	Privacy and data-protection agency (yes/no)	NLD
	Data-protection policy (yes/no)	NLD
	Cookie rules (yes/no)	NLD

Comments: NLD = National legislation database

Apart from the national policies and agencies, it should be mentioned that a number of international bodies are significantly involved in the global regulation of the Internet as a worldwide infrastructure. These bodies include the Internet Assigned Numbers Authority (IANA), which is part of the Internet Corporation for Assigned Names and Numbers (ICANN), and the Regional Internet Registers (RIRs) like the Réseaux IP Européens Network Coordination Centre (RIPE NCC) in Europe. Also, in for instance European Union member states, policies set out directions for national legislation, as in, for instance, the requirement to implement the General Data Protection Regulation

(GDPR). In other words, in analysing the role of the state dimension, some differences will be regional rather than national as a result of, for example, European Union governance, and some similarities will hinge on global governance bodies. This is a useful factor to keep in mind when interpreting comparative results based on the framework. Table 5 shows that the indicator for state regulation of devices and access networks covers state regulation of broadband infrastructures and markets. On the basis of the market coding, we first determine the percentage of state ownership of Internet service providers and then assess whether or not broadband build-out is funded by the state. In order to determine the degree of institutionalisation, we assess whether or not a country has official broadband and 5G strategies and if an official agency is responsible for monitoring and regulating the broadband market. These measures emphasise the degree of influence that the state has on the development and supply of Internet connections through, for instance, enforcement of competition regulation.

The indicator for state regulation of backbone networks reflects the infrastructure and market indicators, as it comprises IXPs, submarine cables, and ASNs. First, we outline the degree of state ownership for the backbone components and determine whether or not the state funds them. Then we question if there are policies in place for routing and peering (net neutrality) and cable landing, and if there is an agency for cyber security in order to assess the degree of institutionalisation of backbone regulation. These measures are critical insofar as the Internet backbone comprises the least officially monitored of the infrastructures, and therefore the area in which commercial power is most prevalent (digital crossroads).

In the indicator for state regulation of applications, we gauge the degree of state involvement in the regulation of websites. Using the market coding, we determine the extent to which the sites in the top-100 list are state owned and assess whether there are established funding schemes for digital public service. Approaching the degree of institutionalisation, we determine whether an official domain-name policy or a government e-inclusion strategy have been enacted, and if a state-appointed body or agency is in charge of public digitalisation. These measures refer back to aspects of globalisation and disruption of markets insofar as the efficacy of state regulation is related to the existence and prominence of national, legacy, and public institutions.

Finally, the indicator for state regulation of content comprises measures of the degree of state involvement in monitoring and regulating digital content and data. Mirroring the steps taken in the other indicators, this includes ownership of third-party cookies and funding of digital content. We also assess whether data-protection policy and cookie rules are inscribed into legislation and if a privacy and data-protection agency is established. For instance, in the European Union, the GDPR constitutes a critical obstacle for market actors that have thus far operated businesses under the radar of state governance.

Conclusions: Where do we go from here?

We set out by arguing that digital media and communication scholars need to orient themselves towards systematic macro studies of digital ecosystems. By combining perspectives from infrastructure studies, Internet governance, and political economy of the Internet, and revisiting the media system analysis tradition, this article emphasises the need for more comprehensive frameworks. On this basis, we offer an analytical

framework for empirical comparative studies of digital communication systems that focuses on the role and interdependencies of infrastructure, market, and the role of the state as key dimensions for analysing digital power structures and governance forms. As such, the article prepares the ground for future studies that consider the various ways the dimensions of our framework interact and co-depend. Comparisons based on the framework will test existing typologies or develop new ones that cluster different national or historical contexts according to factors going far beyond the realm of news media. The advantages of the DCS framework can be summarised in three overall contributions.

First, the DCS framework re-establishes the technological dimension that has played an implicit role in media system analysis and thereby moves infrastructures from the periphery to the centre of systemic communication studies. In doing so, it launches a number of relevant research questions, for instance, concerning the impact of Internet use being primarily based on either mobile or wired technologies; the interdependencies between backbone development and advances in and use of high-capacity applications like artificial intelligence, 5G, virtual reality, or the Internet of Things; or the prominence of national domains and thereby online content in the national language compared to international domains and content.

Second, the DCS framework enables analyses and comparisons of the role and power of global tech companies across different national settings. That is, it acknowledges that national markets are to a wide extent made up by international actors, and it no longer makes sense to limit studies to national market actors alone. Further, by comparing market structures across the value chain (as represented in the four analytical layers), the framework emphasises how digital platform actors today cut across existing sectors and align themselves both horizontally and vertically. A corporation like Alphabet (Google) will in many contexts be a dominant actor across all four layers – as device manufacturer, access network provider, backbone investor, application developer, and content creator.

Third, the DCS framework grounds assessments of the *actual* effects of state policies for digital infrastructures and markets rather than the intentions and discourses that are frequently stressed by policy studies. For instance, studies of Nordic digital media systems (Syvertsen et al., 2014) conclude that, as existing policies and regulatory logics (directed at legacy media) are continued, the strong role of the welfare state is sustained in the face of digital changes. By broadening the analytical scope and assessing the degree of actual state involvement across digital native as well as legacy institutions, the framework poses the question of whether sustained legislation in fact *hits the target*.

The framework has a number of limitations, with the first relating to the critical next step of this research: the actual testing of the dimensions and indicators. Whereas the DCS framework has been employed in a historical analysis comparing the digital communication systems of three historical periods within one national setting (Flensburg & Lai, 2020), it remains to be tested in comparative studies of disparate national domains. Also, there are a number of measures – some of which we refer to explicitly in the sections above – that would have benefitted future analysis, but are unobtainable to researchers and as such, not part of the framework. Many aspects of state regulation as well as market configurations are necessarily omitted, and especially for the market dimension, researchers must put in a lot of time and effort in order to code and thereby produce the relevant data. These limitations aside, we trust that the framework is valuable for future comparisons and contributes to the emergent field of systemic Internet analysis.

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