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Media and Communication (ISSN: 2183–2439)
2023, Volume 11, Issue 2, Pages 319–329
https://doi.org/10.17645/mac.v11i2.6464

Article

Follow the Data! A Strategy for Tracing Infrastructural Power

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Submitted: 7 November 2022 | Accepted: 6 February 2023 | Published: 28 June 2023

Abstract
Recalling the well-known strategy of "following the money" when investigating the underlying power structures and business models of legacy media, this article argues that studies of digital political economies can benefit instead from following the data. Combining perspectives from critical data studies and infrastructure research, we first discuss how direct money flows can be difficult to trace in digital ecosystems, creating a need for alternative analytical approaches for studying and scrutinising contemporary power configurations in digital societies. As a theoretical backdrop, we elaborate on the concept of infrastructural power and apply it in a walkthrough of critical data infrastructures. To illustrate the efficacy of this strategy, we provide perspectives and examples from the political economies of internet infrastructures in Northern Europe and discuss how control over data is translated into economic profit and societal power. In doing so, we argue that increased attention to data infrastructures is needed to advance both critical data and infrastructure studies, improve digital market monitoring, and ground future regulation and policy.

Keywords
critical data studies; data economy; infrastructural power; internet infrastructures; political economy

Issue
This article is part of the issue "A Datafied Society: Data Power, Infrastructures, and Regulations" edited by Raul Ferrer-Conill (University of Stavanger / Karlstad University), Helle Sjøvaag (University of Stavanger), and Ragnhild Kr. Olsen (Oslo Metropolitan University).

1. Introduction

The ubiquitous presence of Big Tech companies and recent political backlashes against their global market dominance have sparked a call for critical studies of the economic transactions and power structures that shape digital communication environments. Over the last decade, we have, for instance, seen a growth in "critical data studies" (Iliadis & Russo, 2016; Kitchin & Lauriault, 2014) aiming to denaturalise processes of datafication (van Dijck, 2014) and surveillance capitalism (Zuboff, 2019), along with an increasing interest in the infrastructures that underlie and support digital societies (Hesmondhalgh, 2021; Plantin & Punathambekar, 2019; Sandvig, 2013). Calling attention to the shortcomings of established methods and analytical frameworks developed in and for analogue media systems, this research has revealed a range of epistemic problems related to obtaining reliable knowledge on the often opaque and black-boxed market structures and modes of governance surrounding digital communication (DeNardis, 2020; Mansell, 2017). As a response to these urgent research challenges, the article suggests that the first step for "following the money" is to "follow the data."

In developing this argument, we first discuss the theoretical implications of studying data infrastructures as political economies by combining classic media and audience studies with perspectives from infrastructures research, thereby advancing the concept of infrastructural power (Mann, 1984; Munn, 2020). Applying this key concept, we then move on to present a walkthrough of the critical components of data infrastructures, arguing that access networks, backbone systems, (first-party) applications, and (third-party) data services provide valuable insights into how digital power is obtained, exercised, maintained, and amplified in contemporary communication environments. To illustrate the strategy, we provide examples of how the various layers of internet infrastructures are organised and controlled within the context of Northern Europe and discuss how control over data is translated into economic profit and societal power. This leads us to conclude that increased attention to data infrastructures is needed to advance both critical data and infrastructure studies, improve digital market monitoring, and ground future regulation and policy.

2. Data Infrastructures as Political Economies

The "follow the data" strategy builds on and contributes to the legacies of political economist media studies by seeking to understand how capital "changes hands" between various stakeholders, and how these economic exchanges influence the structural conditions in (digital) communication environments (Garnham, 1979; Mosco, 2009). Broadly inspired by DeFleur's (1971) efforts to draw up a "schematic representation of the mass media as a social system," we seek to understand the institutional arrangements that shape the internet as a key communication infrastructure in contemporary societies. Like DeFleur, our goal is ultimately to shed light on the crucial but often overlooked "money arrows" that enable the production and flow of information in modern digitalised societies, influencing the capabilities of public and private institutions as well as individual citizens. That is, we look beyond the creation of (symbolic) content to study the production, distribution, and consumption systems as they are shaped by a wide range of (conflicting) interests and business models. In doing so, we answer recent calls for a strengthening of the bond between the classic political economy of media and communication and state-of-the-art infrastructure studies (Hesmondhalgh, 2021).

2.1. Follow the Money

As the main innovation of DeFleur's model, the "money arrow" broke with decades of media research by challenging the emphasis on one-way flows of mass communication content from senders to receivers and pointing to the flows of information going in the opposite direction—from audiences and back to media institutions in the form of audience measurements including target group analyses and rankings (DeFleur, 1971; Ettema & Whitney, 1994). The mapping of financial transactions connecting viewers, listeners and readers, media institutions, measurement companies, and advertising agencies, among others, served as an important foundation for analysing the structural conditions for (analogue) media and for explaining how some media companies gained dominant market positions and continuously expanded their communicative power (Wasko, 2011). As such, DeFleur's efforts to map out the "hidden'' transactions and dependencies underlying the production and publishing of legacy media content serve as a guiding inspiration for critically assessing and uncovering the underlying value chains and dependencies that shape digital markets.

The gradual shift from analogue to digital distribution of mediated communication has significantly altered the conditions for studying these money arrows since digital outlets are embedded in ecosystems of external service providers, intermediaries, and global distribution networks (Nielsen & Ganter, 2018). Digital business models, value chains, and market structures are notoriously difficult to map, with multitudes of money arrows criss-crossing in complex and often obscure ways. While, for instance, ads are a vital source of income for many online service providers, the economic crossfires supporting contemporary audience measurement and ad sales are not easily drawn up. One reason, among many, is that these services are often supplied in a "freemium" manner, making it difficult to trace their business models and money flows. The task of identifying and following key assets in contemporary digital markets is, in other words, both urgent and critical for political economists in the fields of media, communication, and internet research.

While identifying the economic circuits between user measurement, content provision, and advertising is as crucial as ever for understanding contemporary media and communication structures, such studies often neglect to consider the multitude of underlying production and distribution systems. In effect, the "data market" is often seen as detached from the broader digital economy, while it is, in fact—as we will discuss in the examples below—increasingly entangled in the broader infrastructures supporting digital communication. As such, the remainder of this article discusses and explores how an enhanced understanding of the infrastructures that control digital data flows can help researchers and regulators make sense of and ultimately monitor economic power structures in digital environments.

2.2. Critical Data Infrastructures

Following DeFleur's argument above, data exchanges have always been incremental to the double-sided marketplace of attention (Webster, 2014)—in analogue media systems, data came in the form of representative panels that have evolved into today's census counts, or what is often simply referred to as big data. While former approaches collected under the headings of, for instance, "digital tracing" or "digital footprints" have focused on what the comprehensive collections of big data can—or cannot—be used for (Golder & Macy, 2014; Lambiotte & Kosinski, 2014; Lewis, 2015), infrastructural approaches draw attention to the ways data flows are handled and controlled. The "turn to infrastructure" (Hesmondhalgh, 2021; Parks et al., 2015; Plantin & Punathambekar, 2019; Sandvig, 2013) in media and communication studies thus broadly entails a renewed attention to the *material* structures rather than the *symbolic* content of digital communication.

When following the data, we thereby refer to a broader, much more fundamental, and infrastructurally embedded resource in digital ecosystems. Whether people make an online appointment with their doctor, search for shoes via Google, or turn on their smart TV to watch the latest episode of their favourite show on Netflix, their activities are materialised in the form of data flowing back and forth in a distributed network of servers. "Data" is thus defined as the packages that all types of digital content are broken down to when transported over the internet—regardless of whether they contain media content in a conventional sense and flow from content providers *to* individual users, or if they flow *from* users to content providers carrying meta-data about the users' online behaviour, browser history, location, and other valuable information. When sketching out what we refer to as data arrows in digital ecosystems, we focus on the infrastructures that allow these data packages to be distributed between dispersed devices, applications, and computer networks rather than on the specific information they contain.

We thereby contribute to a growing research field aiming to uncover and critically assess the ways architectural and technological arrangements shape human capabilities and societal development and vice versa—be it through, for instance, the everyday governance of monumental data centres (Velkova, 2019), the planning, laying, and maintenance of global submarine cables (Starosielski, 2015), or the control over operating systems, web and mobile applications (Dieter et al., 2019; Gerlitz et al., 2019; Weltevrede & Jansen, 2019), and third-party data services (Binns, Lyngs, et al., 2018; Helles et al., 2020). Building on the broad and diverse literature within the field of infrastructure studies, the strategy of following the data opens up for cutting across otherwise separate infrastructural (and academic) domains—for instance, the backbone industry and the platform economy (Plantin et al., 2018)—and engaging in empirical investigations of the spaces in-between them and the critical dependencies they share.

2.3. Infrastructural Power

While refraining from going into a lengthy, albeit interesting, debate about the theoretical definition of "infrastructure" (see, e.g., Lee & Schmidt, 2018), we will employ a more narrow and conventional use of the concept than what is often referred to as a "deeply relational" understanding that leads researchers to ask not "what" but "when" is an infrastructure (Star & Ruhleder, 1996). When using the concept, we instead refer to the physical resources that enable key societal functions—such as communication. Communication infrastructures, in this sense, constitute the components that senders and receivers continuously rely on, regardless of how or when they are used in practice. These components can be controlled by a variety of stakeholders and be more or less transparent to individuals, nation-states, and researchers. Following perspectives from classic media ecology (Innis, 2007), our ultimate goal in uncovering and studying data infrastructures is to understand how the evolution and institutionalisation of these new infrastructures reshape fundamental societal power structures.

In approaching the relationship between infrastructures and societal power, we build on Mann's (1984) work on infrastructural power. Mann distinguishes between despotic power, understood as the ability of states to exert direct power over individuals (e.g., by imprisoning them), and infrastructural power, understood as the ability to "penetrate and centrally coordinate the activities of civil society through its own infrastructure" (p. 190). Similar to the related concept of institutional power, infrastructural power is exerted through the organisation of societal structures that inevitably influence what people can and cannot do—and not least what choices they have as well as their abilities to imagine alternatives (Mansell, 2002). But while institutional power is discursively constructed and serves as a legitimising and self-regulatory mechanism that naturalise behavioural control through physical means (Foucault, 2008), infrastructural power is materially manifested in the organisation of the physical world (the design of buildings, networks, code, and so forth). The efficacy of institutional power is thereby interchangeably dependent on the infrastructural arrangements that prevail at any given time and in any given context—not least in periods where infrastructures undergo significant changes (Beniger, 1986).

While Mann originally used the concept in relation to nation-states and political systems, we argue that it is highly relevant for understanding political and economic power in a broader sense and, in particular, for making sense of the ways digital infrastructures are organised and controlled by both private and public stakeholders. As we will argue further below, Mann's understanding of states' infrastructural power resembles the current role of so-called Big Tech companies in that it cuts across sectors and, through the design of the physical world, influences the capabilities and activities of individuals and institutions that rely on their systems and services. Prominent examples of this include Meta's decision to close down the Facebook Application Programming Interface, which caused ruptures across the digital industry as so many companies (and academics) had come to rely on it for their business (Bruns, 2019); Alphabet's requirement that phone manufacturers include their services in return for licensing the Android operating system; and their insistence that app developers abide by the rules of the world's largest app store in order to publish their products (Lai & Flensburg, 2021).

The following sections provide a systematic walkthrough of how the concept of infrastructural power can be explored by following the data through the different layers of the internet and investigating how they are owned and controlled.

3. Sites of Infrastructural Data Power: Perspectives From Northern Europe

In mapping the infrastructural arrangements that underly our increasingly datafied societies, we build on former research (Flensburg & Lai, 2019) identifying four main infrastructural layers of digital communication, namely: *access networks* that allow users to connect to the internet and thereby send and receive data; *backbone systems* that enable these networks to exchange data with other operators and networks; *applications* in the form of, for instance, websites and mobile apps that present the data for the user through an interface; and finally, technologies for storing, processing, analysing, and distributing (meta) *data*, often provided by external third-party services. The four layers of internet infrastructure are illustrated in Figure 1, which also depicts

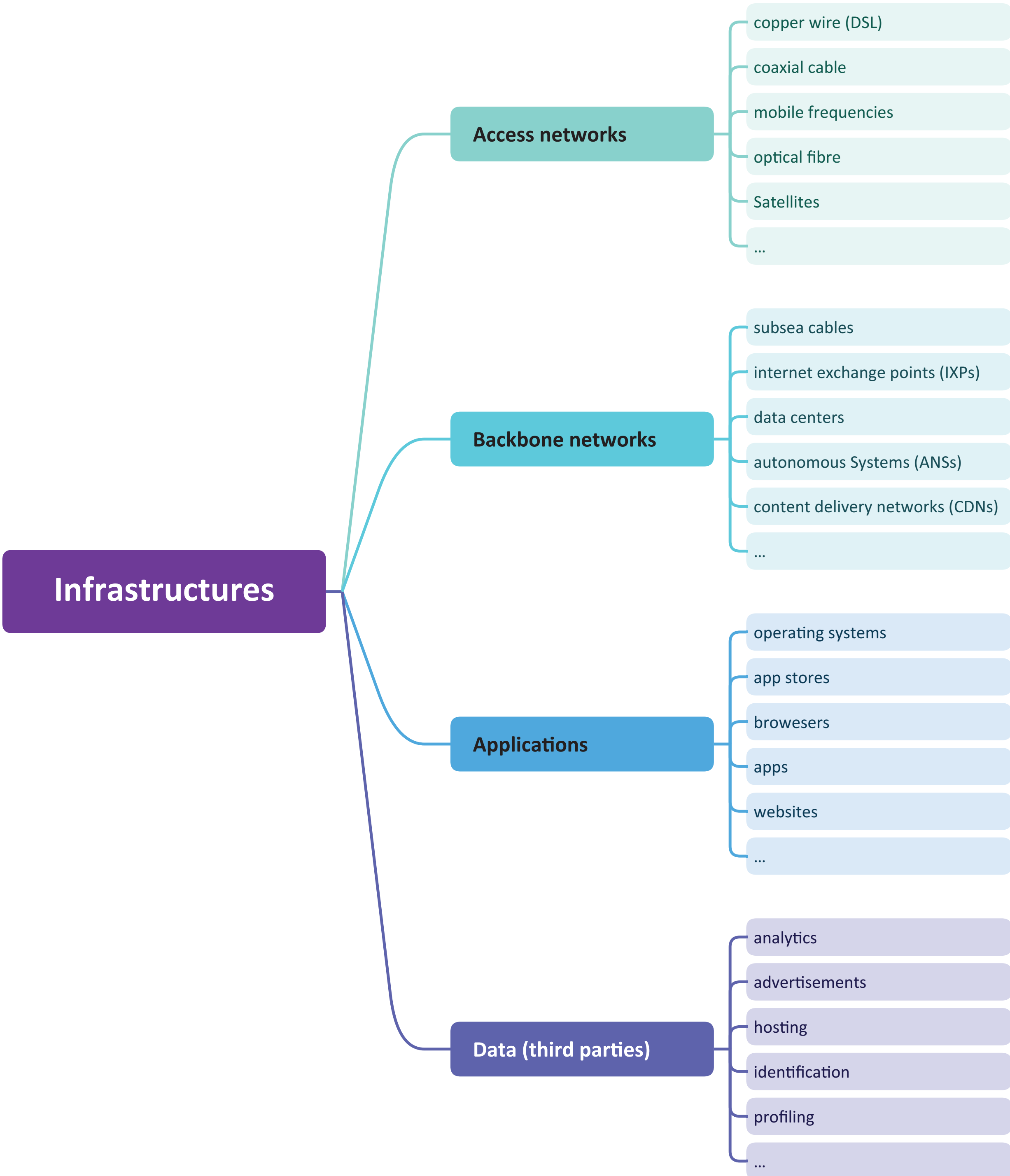

Figure 1. Four layers of internet infrastructure and their infrastructural components.

examples of their specific components (e.g., the different types of access networks, backbone systems, applications, and third-party data services).

This perspective enables us to map out infrastructural dependencies in and across the digital ecosystem. We can, for instance, uncover how access networks depend on backbone systems when exchanging data with other network operators or how providers of online services rely on externally provided tools for data processing, storage, and distribution. We can also begin to shed light on and question the various economic transactions involved in exchanging data between different layers. For example, when access networks charge users but pay other operators for routing and peering; when applications put up paywalls and sell ads but also pay for, for instance, content delivery networks (CDNs), cloud solutions, and analytics; and when third-party services offer tools and services "free of charge" while monetising them in other ways.

Illustrating how the strategy can be applied, the following sections provide examples from the context of Northern Europe to discuss how the different components of the internet serve as economic assets and sites of infrastructural power within specific societal contexts. More specifically, we provide examples of (a) how the economic conditions for running and using a digital service are framed by the data infrastructures in which they are embedded, and (b) how dominant market actors in the digital realm use these data infrastructures to obtain, maintain, and expand their infrastructural power.

3.1. Access Networks

Local access networks constitute the first stop—or last mile—of the internet by allowing individual internet users or services to send and receive data through, for instance, a fixed (copper wire, coaxial, fibre optic) or mobile (e.g., 5G or satellite) connection as sketched out in the upper right corner of Figure 1. Having the power to connect or cut off individual users, specific communication services, or entire communities (Benjamin, 2022; Krapiva et al., 2022), internet service providers (ISPs) are crucial gatekeepers in the digital ecosystem. As a result, the access network layer is rigorously monitored in statistics of internet penetration, connectivity, and coverage (Access Now, n.d.; European Commission, n.d.; ITU, n.d.; OECD, n.d.), making this layer of internet infrastructure relatively transparent to both researchers and regulators.

Since the structural conditions for supplying, and thus using, broadband services differ significantly depending on the underlying technology, access networks are prime cases for investigating the relationships between physical infrastructures and political economies. The earliest forms of broadband connections in the Nordic region were, for instance, based on extensive landline (copper wire) telephone networks and later (coaxial) cable TV systems, making it fairly easy for legacy telecommunications companies to position themselves in the emerging ISP market. As the market has matured and the demand for high-capacity connections has grown, optic fiber networks have been rolled out, many of which utilise existing electricity grids, while mobile networks have gradually improved to the point that they can now offer an alternative to fixed broadband subscriptions. The increasing competition over network traffic has evoked intense power struggles between network operators, who are investing billions of euros in updating and developing their services.

The competition between fixed and mobile networks constitutes one of the clearest examples of infrastructural power at the access network layer and, unlike what we will see in the next infrastructural layers, it is largely politically determined. Since the electromagnetic spectrum used for mobile networks is a scarce resource, it is allocated and assigned by state authorities, meaning that questions about whether or not to release spectrum for mobile communication and how to price and assign frequencies are highly political matters (Ala-Fossi & Bonet, 2018; Martínez-Santos et al., 2021). By holding back the allocation of frequencies or selling them off at high prices, governments can—deliberately or not—delay the spread of mobile broadband and thereby create an advantage for fixed broadband providers. In contrast, the current investments in and rollout of 5G are making mobile data subscriptions a strong alternative to fixed internet, thereby possibly weakening the incentives for users to pay for an additional (fixed) internet subscription. In the Nordic region, these tensions are apparent: Finland tops the global charts in terms of mobile data consumption and subscriptions as a direct result of the country's early allocations of spectrum, which made mobile networks widely available. In contrast, terrestrial (fibre optic) networks are scarce compared to neighbouring countries such as Norway and Sweden, which largely rely on fixed connections (International Telecommunication Union, n.d.). In Norway, in particular, spectrum has been auctioned off at a high cost and mobile data subscriptions are expensive, making fixed broadband more attractive for users as well as operators.

As another example of how infrastructural arrangements play into economic power structures, the internet's success and the Nordic countries' comprehensive digitalisation have altered the basic conditions for developing and supplying access networks. While legacy telcos such as Danish TDC, Finnish Elisa, Norwegian Telenor, and Swedish Telia continue to dominate the ISP market in the Nordic region, their original sources of income and, for some, their ability to make new infrastructural investments have been severely debilitated by the rise of so-called over-the-top services that provide web and app-based alternatives to classic telecommunication services such as telephony and traditional TV distribution. While the access network market, for now, continues to be controlled by traditional telecommunications operators, Big Tech companies originating in the applications and data layer show increasing interest in building and running access networks outside the Nordic region. Facebook's mother company Meta is, for instance, collaborating with established network operators on mobile connectivity projects where basic versions of Facebook's products can be accessed free of charge (Eisenach, 2015), while Google (owned by Alphabet) supplies high-speed fibre networks in selected American cities (Lam, 2017).

These examples illustrate a central tension in the digital ecosystem where former network operators lose their exclusive positions as service providers, while digital service providers increasingly invest in underlying network infrastructures (Plantin et al., 2018). These investments can be seen as proprietary efforts to control the entire value chain underlying data traffic: from the collection and initial transport of data packages to service operations and third-party service provision. By supplying and controlling their own access networks, Big Tech companies can obtain independence from other service providers while also potentially channelling users towards their own services (e.g., the Google search engine or Facebook's website). Interestingly, these commercial strategies largely resemble the former business models of legacy telcos that would also control entire value chains: from the supply of vital communication services (such as telephony) to the underlying network infrastructures connecting dispersed terminals. As telephone companies increasingly become ISPs, they inevitably give up this market advantage and grow dependent on other infrastructure operators enabling them to enter the global network of networks. Returning to Figure 1, this creates a direct data (and money) arrow between the infrastructural layers of access and backbone networks and the companies that control them.

3.2. Backbone

Often described in vague and obfuscating terms such as the "cloud," the extensive cable networks, exchange hubs, and data centres located beyond the last mile of access networks constitute a materialisation of what the internet essentially is—a (global) network of networks. For this article, we stress three backbone components serving as key sites of infrastructural power in contemporary digital societies, namely: internet exchange points (IXPs), submarine fibre optic cables, and CDNs, each of which is represented in the second branch of Figure 1. While these examples do not provide a comprehensive account of the highly complex global backbone infrastructure (e.g., terrestrial dark fibre networks and data centres are difficult to map), they make up key physical resources supporting the exchange and transport of data and can be studied through various types of publicly available information sources and databases.

Providing the (physical) facilities that enable dispersed access networks to exchange data with each other without having to establish individual peering points, IXPs make up a critical component of the contemporary internet infrastructure. In the Nordic region, the first generation of IXPs was established by national institutions (often universities) in the 1990s, following the growing demand for internet peering and routing. In recent years, the number of exchange points has increased significantly, with some of the largest being placed in Amsterdam, Virginia, and Hongkong, and a number of multinational companies such as the US-based Equinix and Russia-based DATA-IX running facilities in, for instance, Denmark, Finland, and Sweden (see Internet Exchange Map, n.d.). The IXPs hold tremendous infrastructural power by determining the conditions for peering and thereby influencing the global economy of the internet (e.g., what ISPs and other network operators need to pay to interconnect).

As another critical backbone resource, submarine fibre cables create links within and between countries, regions, and continents separated by sea, thereby allowing for the transfer of global internet traffic (Starosielski, 2015). Constituting an important infrastructural foundation for the spread of the internet—and not least the exponential use of US-based services in the 2000s and 2010s—the first generation of submarine internet cables were laid between the late 1980s and early 2000s by large consortia of national telcos. With an anticipated lifespan of 25 years, many of them are currently being retired or superseded by higher-capacity cables (Routley, 2019), often funded by other types of corporations and institutions—including American Big Tech companies such as Alphabet and Meta that in recent years have invested significantly in global cable routes (Clark, 2016). The submarine cable market, however, continues to be inhabited by a diverse group of stakeholders reflecting geopolitical contexts and national power structures (Winseck, 2017, 2019). In Northern Europe, Norway is, for instance, characterised by a relatively high degree of national infrastructure ownership, unlike Denmark, where foreign investments are more common. Further research is needed to conclude whether these differences result from regulation and policy decisions, geographic features, or economic interests.

The final example of backbone infrastructures creating important data—and money—arrows in the digital economy are the CDNs used by, for instance, streaming services to prevent network congestion when distributing high-capacity content. As a crucial innovation in the evolution of the internet, CDNs solved an inherent challenge of the internet's point-to-point architecture by moving content away from the producer and placing it (temporarily) at the opposite edges of the network, close to the end-user (Sandvig, 2015). This requires significant collection and analysis of user data since CDNs need to know—and predict—what content to store where (Helles & Flyverbom, 2019), linking this part of the backbone directly to the data layer, described later in the article. The first and globally leading CDN company is US-based Akamai which supplies services to a multitude of content providers (BasuMallick, 2022), followed by Amazon's CloudFront, which offers integration with its immensely popular cloud solution (AWS), while Microsoft Azure, CasheFly, and Cloudflare provide alternative CDN solutions. In the highly digitalised Nordic region, the users' growing preference for streaming pushes up the expenses for media outlets and public service institutions, who have to both maintain their original distribution system (e.g., broadcasting and print) and invest in digital network services (including, but by no means limited to, CDN).

All in all, the control of backbone infrastructures constitutes one of the most critical and black-boxed forms of infrastructural power. Without access to central peering points and data highways, access network operators would not be able to exchange data, and users would be unable to use services located beyond the confines of their local networks. Service operators wishing to make use of the global market potentials created by the internet are, in other words, highly reliant on efficient and accessible backbone infrastructures and their service conditions. This, along with the capacity-demanding ambitions such as developing the internet of things and the metaverse, provides explanations for so-called platform companies' recent investments in the backbone market while also creating a link to the next layer of the internet infrastructure, namely that of applications.

3.3. Applications

Moving to the third infrastructural layer of Figure 1, digital applications provide the interfaces and services that make the internet useful for individuals and thereby essentially trigger the sending and receiving of data. Whenever a user activates a digital service, data is sent to the servers hosting the application, requesting that the applications return data to the individual. Application infrastructures thereby refer to the physical servers of websites and apps but also to operating and domain name systems, web browsers, and app stores. Since the content of these services is often hosted on external servers and in CDN caches, cloud services and CDNs are closely linked to the application layer. For this article, however, we emphasise the infrastructural and economic relationships between websites and browsers and between mobile apps and app stores since these constitute clear examples of how infrastructural power is obtained and exercised in contemporary digital economies.

As the "killer application" of the early internet (Naughton, 2016), the World Wide Web (www) holds an important key to understanding the public breakthrough of digital communication and the rise of the digital political economy. Providing a common coding language and hyperlink protocols, it allowed for website programming, web searches, browsing between data stored on different servers, and much more. To access a website, users need a web browser that presents the requested content in a comprehensible format and allows the user to enter URLs and navigate between different websites. As a key characteristic of web-based communication, websites are not browser-specific, meaning that any website can be accessed from any browser and that the supply of browsers does not constitute a business model as such. Most browsers are therefore owned by corporations that are based on other related revenue streams such as advertisement (in the case of Alphabet's Chrome browser), device manufacturing (in the case of Apple's Safari browser), or software development (in the case of Microsoft's Edge).

The introduction of smartphones, mobile networks, and apps constitutes another key moment in application history as it released digital services from their previous reliance on (stationary) computers, fixed network connections, and web browsers. The success of mobile apps has evoked an infrastructural rearrangement of the basic conditions for supplying—and using—digital services since mobile apps are installed on the users' devices and, therefore, must be custom-made for the different operating systems. This means that app stores take over from browsers as the main gatekeepers in the application ecology—but with the important difference that individual apps must develop specific versions for different operating systems and make them available in different app stores (e.g., Google Play for Android devices and AppStore for Apple devices). Contrary to web browsers, app stores require apps to pay a percentage of their profit (typically 30%) and can remove apps as they see fit. As such, mobile apps are developed and published in more closed-off environments than initially imagined with the development of the open web (Berners-Lee et al., 1992).

The implications of these infrastructural differences stand out clearly when we turn to the specific context of Northern Europe, where the web and app ecologies are characterised by similarities but also significant differences. While the national web ecologies, to a wide extent, reflect historically anchored market structures in the different Nordic contexts with a strong presence of, for instance, legacy media institutions (e.g., Norwegian Schibsted, Swedish Aftonbladet, Finnish Alma Media, and Danish JP/Politiken) and national public service institutions, the app ecologies are more similar and globalised across the region. Looking at, for instance, the most used apps, Google (Alphabet), Facebook (Meta), Samsung, and Microsoft dominate, while apps developed for and by state authorities (e.g., health services, identification, public communication platforms) make up most of the (minority) of nationally specific apps amongst the most used.

The application layer, in other words, constitutes a clear arena for studying contemporary infrastructural power exertion, where the architectonical principles and design choices are intrinsically linked to the political economies that evolve around them. Since the prevalence of free of monetary charge services makes digital market dominance and revenue streams difficult to trace, the amount of data traffic travelling to and from the servers and domains of immensely popular websites and apps constitutes an important object of study that is in urgent need of methodological innovation and systematic analysis. In mapping out these market structures, it is essential to consider the infrastructural environments that shape them (e.g., operating systems and app stores) and to consider how dominating suppliers of devices, operating systems, key applications, and network services directly or indirectly shape usage patterns and competition structures. However, the infrastructural entanglement of applications in the underlying data economy is even more crucial when seeking to understand the data and money arrows of digital ecosystems.

3.4. Data

By now, we hope to have made a convincing argument for seeing all the resources described above as essentially being data infrastructures in so far as they enable (or constrain) the transfer of data packages between senders and receivers. As such, it might seem incongruous to label this last part of the digital infrastructure (the bottom right corner of Figure 1) as the "data layer." Yet, we do so to emphasise that these infrastructural arrangements support what we commonly refer to as the "data economy"—understood as the economic structures supporting the *processing* and *handling* of user (meta) data—be it by controlling network capacity and speed, troubleshooting, tracking users' web history, registering location information, serving ads, or any other purpose (Libert, 2015). Following the data arrows into this often hidden and implicit part of the digital ecosystem reveals important dependencies between third-party operators and application providers, and it enables us to enquire into how and why user data has become one of the most valuable resources in the digital economy.

While data transport is essential to any internet-based communication, the early phases of digitalisation were surprisingly free from registration and tracking. In fact, the anonymity and one-way flow of information characterising the early web was a major obstacle for especially those emergent e-commerce initiatives where registration of purchases and payment information were critical. The later infamous "web cookie" became the solution by making websites capable of storing and tracking user data to, for instance, remember user preferences, profiles, and search history (Naughton, 2016). In time, web cookies became the spine of online advertisement, replacing more or less representative panels with big data collected through users' browsers and providing more granular and wide-ranging information on their preferences and behaviours to encourage them to make future purchases (Zuboff, 2019). The cookie market has gradually been taken over by companies such as Alphabet, Meta, and Amazon that have bought up a range of third-party services while simultaneously using—and nurturing—the user information collected from their own immensely popular applications (Falahrastegar et al., 2014).

Similar to and as a direct consequence of the development in the application layer, the introduction of smartphones and mobile apps has extended and disrupted the data market. First and foremost, the penetration of digital communication into almost all spheres of everyday life has enabled more comprehensive data collection, including location tracking. Furthermore, unlike websites, mobile apps are built in a modular fashion where third-party services are integrated into the very architecture as building blocks rather than as later add-ons (Dieter et al., 2019), making it more difficult to opt out. And finally, the more closed-off environments of mobile apps also mean that the large operating system and app store suppliers (Alphabet and Apple) have even stronger positions in the app-based third-party environment than in the web sphere (Binns, Zhao, et al., 2018). The ongoing concentration of power across the application and data layer is, in other words, infrastructurally rooted as the dominant market actors serve as important gatekeepers controlling operating systems, browsers, and app stores, while also providing the tools and services on which their competitors rely.

Directly reflecting the different power configurations in the Nordic application marked outlined above, the control over third-party services also differs significantly when comparing web and mobile third-party infrastructures. Studies of third-party services in websites (Helles et al., 2020) and apps (Binns, Lyngs, et al., 2018; Kollnig et al., 2022) show that (in)famous third-party services such as Google Analytics and other highly successful products provided by Alphabet, appear on more than half of the top websites and apps. In the Nordic region, the Norwegian legacy media company, Schibsted, is a (not so close) second runner-up in the Nordic web cookie market due to its provision of services to news sites, especially Nordic ones—while Nordic third-party services are next to non-existent in the mobile app market (Flensburg & Lai, in press). This clearly illustrates how the gradual shift from "the open web" (Berners-Lee et al., 1992) to the more walled-off environments of mobile apps entails a significant altering of the infrastructural power structures where the (data) rich (Andrejevic, 2014) become richer while the (data) poor continuously contribute to the success of their largest competitors by relying on their (data-driven) services.

By following the data beyond its "known" destinations (the requested website or app) and identifying the wide range of companies collecting, storing, analysing, and feeding data back to applications and users, we can get a glimpse into a largely hidden but equally crucial part of the digital infrastructure—and market. This allows us to study and scrutinise how design choices and continuous system updates are linked to corporate strategies and can help explain increasing market concentration. The ever-growing data economy, in turn, serves as a foundation for the constant expansion of Big Tech's infrastructural power as it fuels investment in other parts of the internet infrastructure, thereby ensuring sufficient capacity and efficiency of their increasingly advanced services and drawing up new data arrows from this part of the infrastructures and back to the latter three.

4. Conclusion

Concluding this walkthrough of critical data infrastructures, we hope to have demonstrated what researchers can gain from following and drawing up data arrows as means of identifying economic transactions and money flows in digital ecosystems. Returning to the introductory ambitions of combining the questions asked by critical data studies with the empirical and analytical approaches of infrastructure studies, the strategy and examples discussed above provide a foundation for further investigations of the market structures and economic arrangements surrounding ongoing processes of datafication. Infrastructure research can, in turn, benefit greatly from developing theoretical frameworks and critical research questions to substantiate its strong empirical contributions. Or to sum up, following the flows of data as they travel through and across geopolitical contexts, sectors, and institutional arrangements fosters a broader understanding of the data economy and how it can be studied—and ultimately, regulated.

When cutting across the different internet layers and sites of infrastructural power, we begin to see the contours of a multitude of data and money arrows that ground commercial power structures in datafied societies. The "follow the data" strategy allows us to scale up from specific case studies and particular flows of data to investigate, map, and monitor the macro structures that currently are subject to little democratic scrutiny. By applying the strategy, we gain deeper insight into the conditions for running a digital business and extend our understanding of how and why a handful of companies obtain increasingly powerful positions in the digital ecosystem. Such efforts are pivotal since companies such as Alphabet continuously extend their infrastructural power across the value chain: from being a global leader in the applications and data market to increasingly investing in backbone and even access network infrastructure. Through these investments, Big Tech companies become increasingly independent of other actors while simultaneously making other market actors increasingly dependent on the company's infrastructures.

Conflict of Interests

The authors declare no conflict of interest.

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